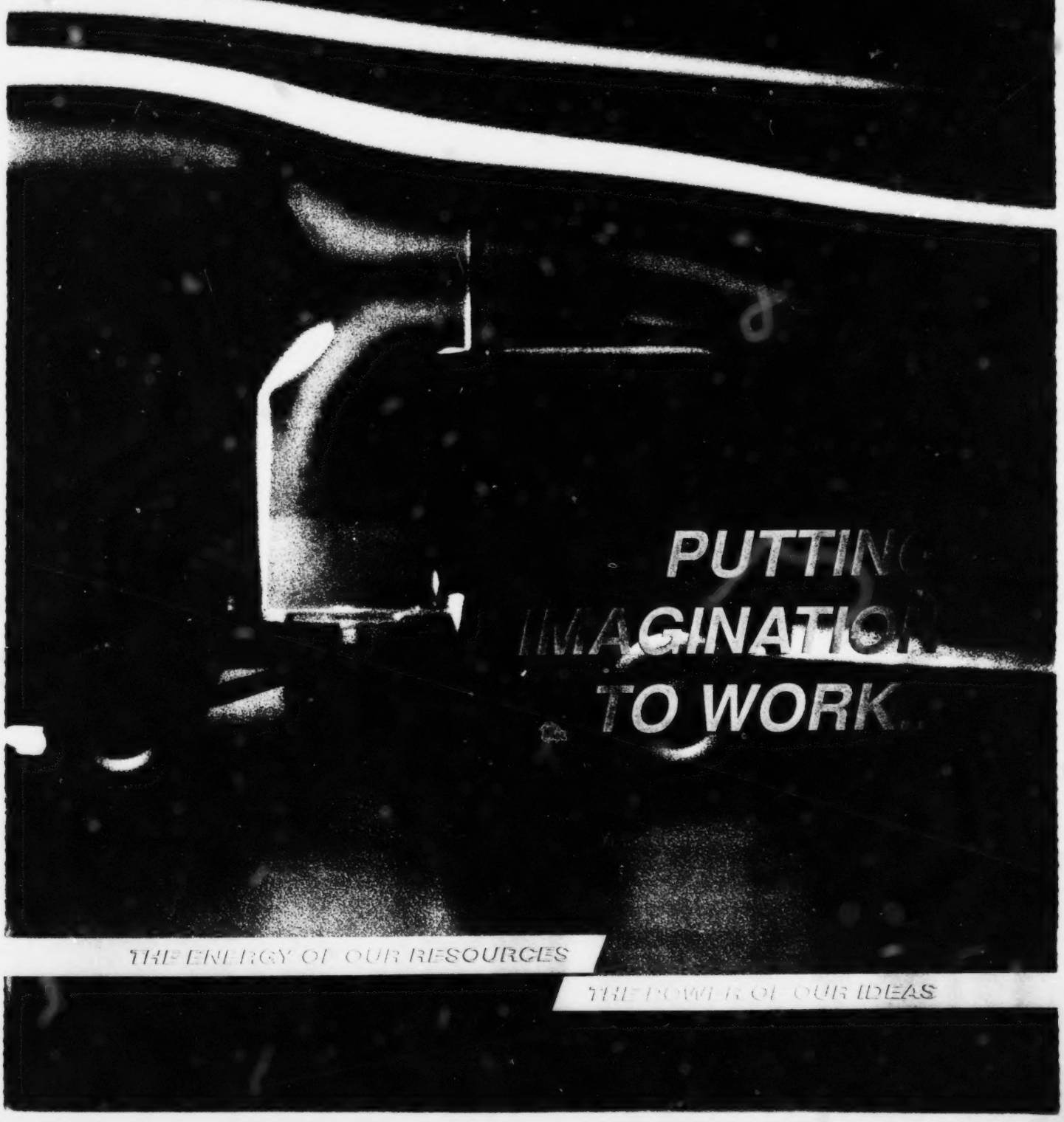
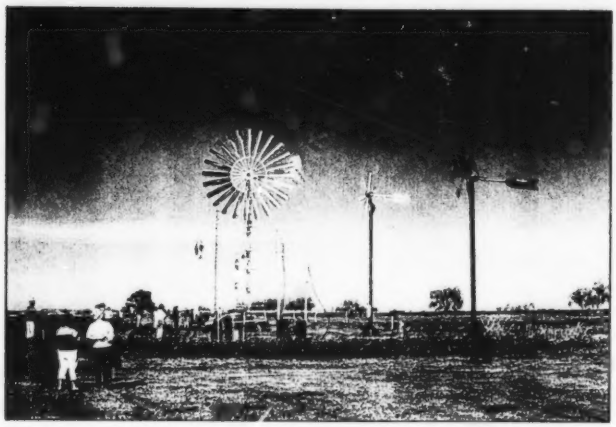
Energy, Mines and Resources Canada
Énergie, Mines et Ressources Canada

THE FEDERAL ENERGY R&D PROGRAM





Service evaluation of wind machines for pumping and power generation at the Lethbridge, Alberta test site.

Cover photo: *Wind tunnels used to design trucks for lower fuel consumption.*

Back cover photos, top to bottom: • *Reducing heat loss in windows through development of improved sealants* • *CANMET optimizing coking conditions for Canadian metallurgical coals* • *Improved heavy rail car bogeys developed by Transportation Development Centre to reduce rail wear caused by heavy coal trains.*

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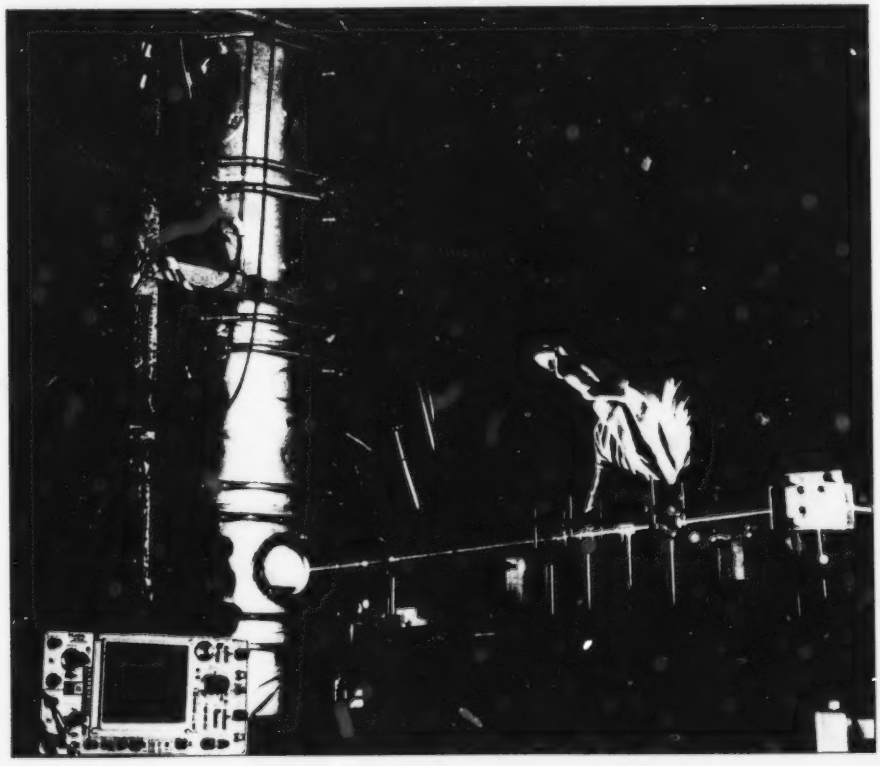
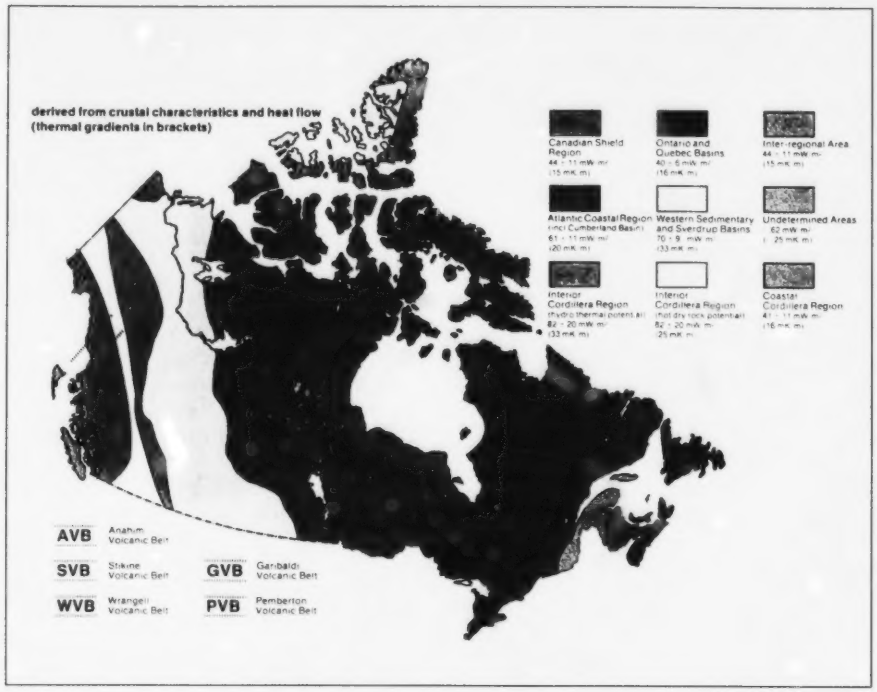
Putting Imagination to Work...

Since 1974 the federal Energy R&D Program has been helping Canadians develop new technologies and create opportunities for the future. Working through 13 federal departments and agencies, in areas as diverse as domestic furnaces and global warming, the program has generated economic benefits to companies and individuals throughout the country, while broadening the base of knowledge necessary to protect the health of our people and the well-being of our environment.

The purpose of this booklet is to give you the opportunity to learn more about this wide-ranging organization and the important contribution it has made to Canadian life. The booklet does not concentrate on technological or administrative processes. Rather, it emphasizes results: new developments, companies, jobs. We believe that a survey of these results, presented in the form of examples and case histories, will enable you to consider the federal Energy R&D Program in the true light of its past performance, its present direction, and its ongoing value to the Canadian people.



Laser-measured combustion inside a furnace.



Geothermal regions of Canada.

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All human activities are dependent on food and energy. And when either threatens to become scarce, we pursue every practical measure to secure supplies. In the early '70s, emergent uncertainties about the price and availability of fuels, particularly oil, forced us to turn our attention to energy.

During those difficult days, the insecurity of our condition brought home the reasonableness of two long-term courses of action. We recognized, first of all, that we had to broaden our options and increase our adaptability by developing additional sources of energy. Secondly, we saw that we had to learn how to use present energy sources more efficiently.

Along the way, we also came to realize just how hard certain practices can be on the environment. Acid rain, world population growth, the greenhouse effect, nuclear energy mishaps, oil spills, increased reliance on automobiles—all these have come about in the course of contemporary energy production and use.

But besides turning Canada toward a new set of energy goals, the supply scares and environmental stresses of the recent past also made us more aware of how these goals were to be reached. It became obvious that the know-how and equipment needed to respond to ever-changing energy and environmental conditions required a high-quality research and development capability.

In 1974, then, the government instituted the federal Energy R&D Program and formed the Interdepartmental Panel on Energy R&D to manage it. The program deals with all aspects of energy except nuclear fission, which is the responsibility of Atomic Energy of Canada Limited (AECL).

Canada's research and development capability is a matter of national concern. We believe that the Energy R&D Program's contribution to this capability has been invaluable. And we believe that, in continuing to build on the technological accomplishments of the federal Energy R&D Program, we shall be helping to build a Canada that is economically strong, environmentally sound and scientifically alive.

Five-thousand-barrel-per-day hydrocracking demonstration plant at Petro-Canada's Montreal refinery. This hydrocracking process was developed at the Canada Centre for Mineral and Energy Technology (CANMET).

Why the Government Conducts R&D

Canada is an energy-rich country, but to benefit Canadians fully, our energy resources must be developed and extracted in ways that are safe, efficient and, above all, respectful of the environment. Finding these ways, which must constantly be adapted to changing economic and technological conditions, is one of our greatest R&D challenges.

Although much of our research and development is carried out by industry and the universities, the federal government also has an essential role to play in furthering Canada's energy R&D capability. There are two good reasons for this. First of all, the market forces that drive our energy industries do not operate far enough into the future to affect important fields such as energy diversification, health and safety standards, and the environment. Secondly, extensive, multidisciplinary projects are very difficult to manage in a university setting.

The federal government, therefore, conducts medium- to long-term R&D that is essential to the public good, and that otherwise would not be done.

The federal Energy R&D Program: benefiting all Canadians

From this R&D, undertaken by the federal Energy R&D Program, benefits accrue in a number of important areas.

International Competitiveness Technological innovation permits industry to take full advantage of Canada's lower energy costs, thereby increasing trade and with it the wealth necessary for investment in business, education, health care and social programs.

Regional Development R&D increases trade, standards of living and quality of life in *all* regions of the country.

Energy Efficiency R&D shows us how to get more out of the energy we use, thus increasing the domestic availability of energy, reducing the risk of environmental damage, and saving Canadians a lot of money.

Industrial Growth By sharing costs to reduce the risk of performing and implementing R&D, the program encourages nationwide industrial innovation. Spinoff benefits include new products, businesses and jobs.

Energy Diversification R&D helps us to ensure reliable supplies of energy through variation and substitution of energy sources.

Health and Safety The federal Energy R&D Program has helped enhance levels of health and safety throughout the country, providing us with the knowledge we need to set appropriate standards, as well as the means to determine whether these standards are being met.

The Environment More than half of the federal Energy R&D Program is related to the environment. The program's work gives government the scientific base required to formulate sound environmental policy, a matter of increasing public concern. In addition, energy R&D enables us to relieve pressure on the environment through more efficient energy use, and gives us access to technologies that are more environmentally benign.

Changing Times

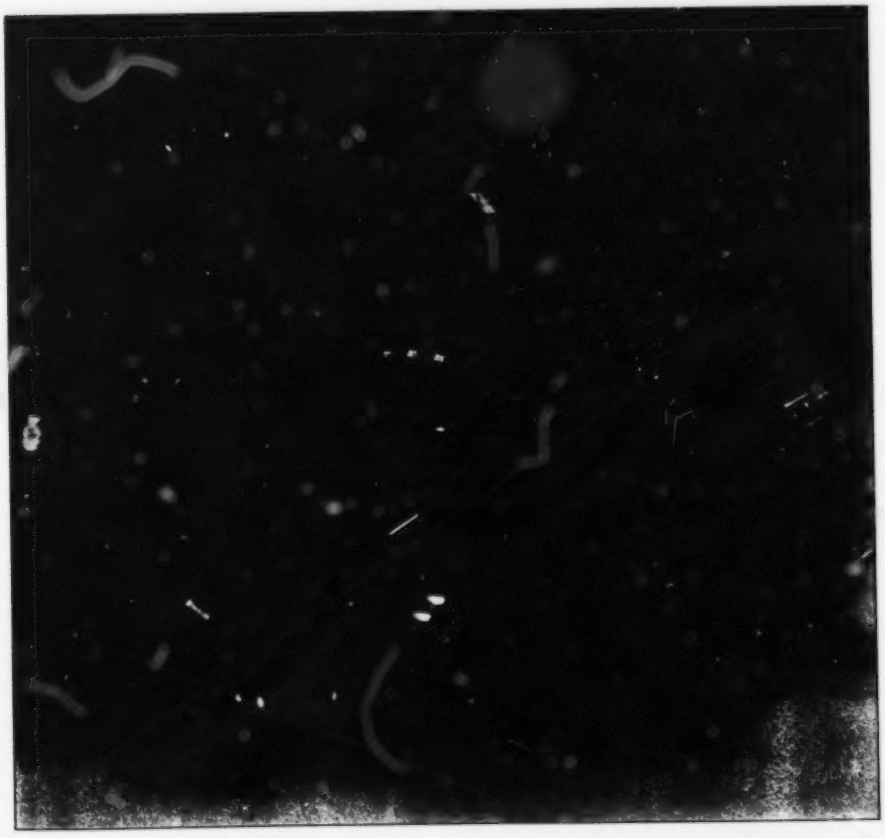
Since the end of the World War II, trade and communications between nations have increased so rapidly that our whole notion of commerce has changed. A truly global economy has emerged, and economic success now depends on effective participation in the highly competitive global marketplace.

During this transition, trade and technology have become more closely intertwined than ever before. Technology-based innovation has become the driving force behind the movement and creation of tradable goods and services. Without it, full participation in the new global economy is impossible. And without the benefits of modern trade, no nation can realize its potential, or even maintain itself according to its choice. The wealth that trade creates provides more than direct economic returns. It also forms the necessary resource base for investment in education, health care and social programs.

To achieve the innovative capacity required to remain competitive in the world marketplace, a nation must adopt bold and effective research and development strategies. And this means using a whole range of institutions to concentrate energy resources (which are essential to all economic activity), technical expertise and commercial initiative. Since 1974 the federal Energy R&D Program has been working with industry, with the universities, and in government laboratories to help make this concentration possible. The following examples illustrate some of the program's present and emerging benefits.

Technology-based innovation: the key to social progress

The federal Energy R&D Program: paving the way



Stackpole Ltd. manufactured these automotive components from steel powder. This process, called powder metallurgy, essentially eliminates the need for machining.

Powerplex

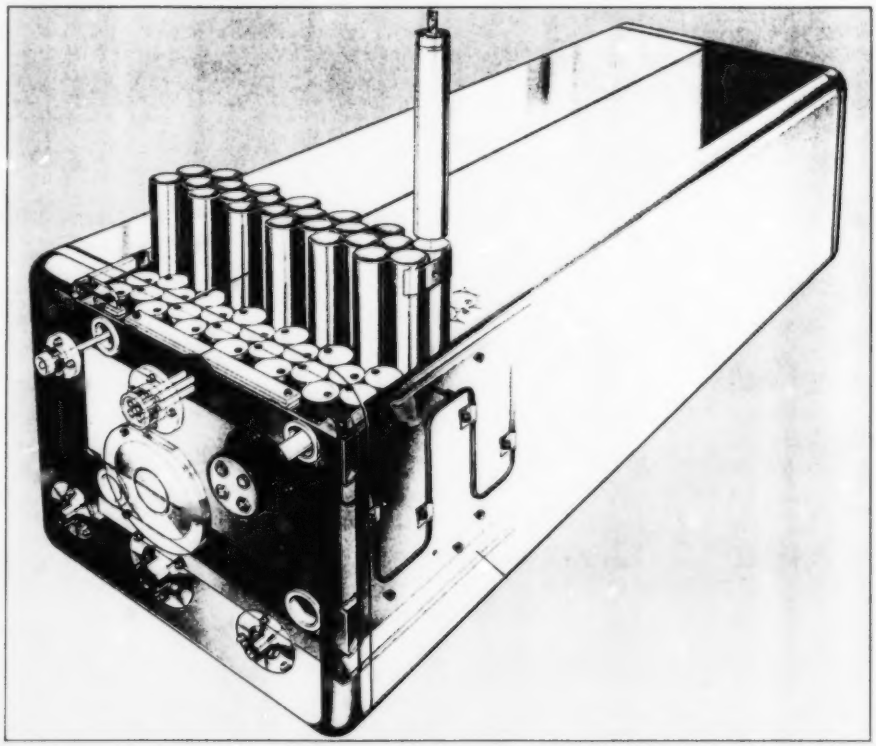
A new battery being developed in Toronto by Powerplex Technologies Inc. could make clean, quiet, easy-to-operate electric cars practical at last. Powerplex was established three years ago when Brown, Boveri & Cie (BBC) of Mannheim, West Germany and Magna International Inc. of Markham, Ontario decided to pool their respective skills in engineering and automotive parts production.

Various attempts had previously been made to power vehicles with electricity from lead-acid batteries. But except for some success in short-haul delivery vehicles, the results were disappointing. The lead battery's low power relative to its weight made for short travel ranges, poor acceleration and small payloads.

Preparing battery-operated vehicle for road test.

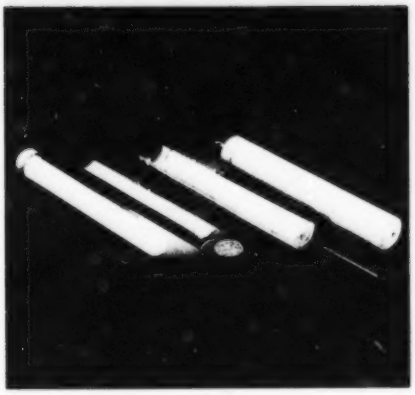
The sodium-sulphur battery has the potential to overcome these problems. And Powerplex, with the complementary expertise of its founding partners, is one of the leaders in the race to make electrically powered vehicles a practical option.

As work on the sodium-sulphur battery continues, so do advances in battery-powered vehicles. The Ford Motor Company is now



Prototype sodium-sulphur battery.

Powerplex



employing Powerplex technology to develop vehicles with substantially greater range and performance. For future commuter autos, top speeds of 130 kilometres per hour and ranges of 250 kilometres between recharges are now considered feasible. And in the United States and Japan, power companies are investigating the load-leveling possibilities of larger sodium-sulphur batteries in electrical power stations.

Because of the high risk of this project, the possibility of reduced dependence on liquid fuels, and the opportunity to lower exhaust emissions in cities, the federal Energy R&D Program, through its Industry Energy Research and Development (IERD) program, contributed $4.9 million to Powerplex's effort, supplementing a previous seed-money grant of $500 000 from the National Research Council. This seed money allowed Powerplex to bring into play NRC's fundamental work on this battery.

According to Powerplex, this development will "employ hundreds directly, create new industrial opportunities, reduce air and noise pollution, and decrease our dependency on petroleum."

Ice Slurries

Sunwell Engineering of Woodridge, Ontario has developed a cooling system that can save as much as 60% in operating costs. In this system, a special brine solution is chilled so as to produce a thin mixture (or slurry) of ice crystals that remains cold enough to refrigerate and fluid enough to pump. In fact, the cooling capacity of the resultant ice slurry is far greater than that of conventional refrigeration liquids.

Originally developed in response to the special refrigeration needs of fishing vessels on the Great Lakes, the system has since proven effective in many other applications, from air-conditioning Japanese highrises to cooling parked aircraft.

In its larger applications, the system provides a way of leveling the electrical loads necessary for refrigeration and air-conditioning, using cheaper off-peak electricity to produce and store ice slurry for more expensive periods of peak load.

Sunwell's ice-slurry refrigeration offers another example of a successful technology that would never have been developed without some help from the Energy R&D Program.

Water-Based Paints

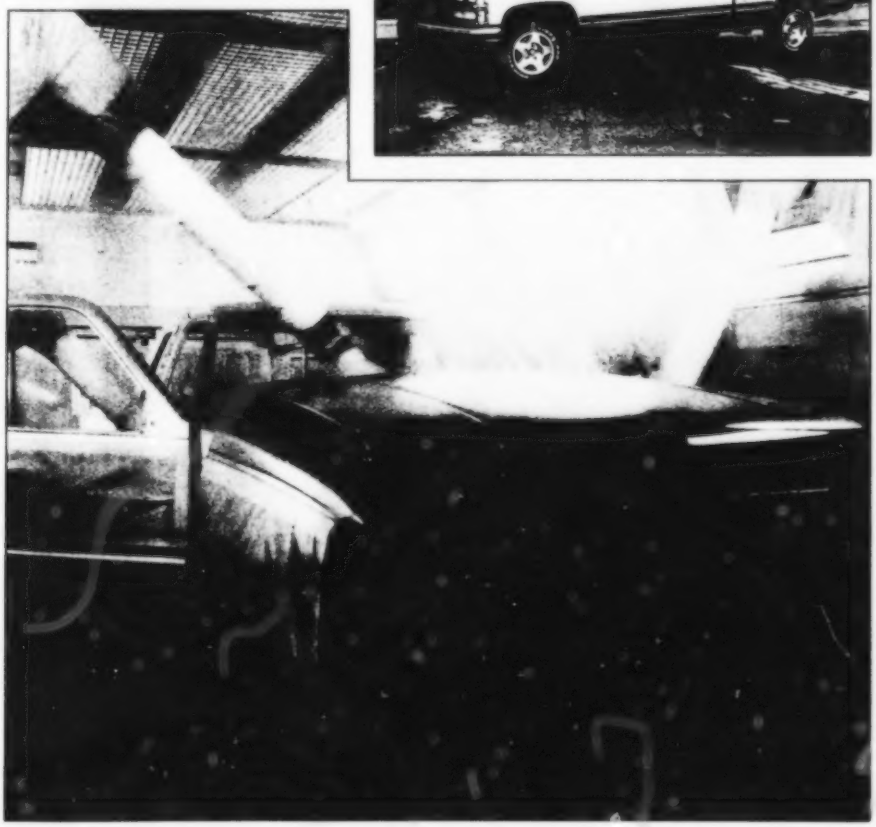
C-I-L Paints of Toronto has perfected a new automotive paint process that not only produces a better finish but also reduces air pollution and saves energy. Following an extensive cooperative development program, General Motors of Canada Limited has adopted the process in the truck assembly plant at GM Autoplex in Oshawa. GM is already considering the use of the new paint at other facilities, and other major automotive companies have also expressed strong interest.

The waterborne paint, called Aquabase, was conceived using latex technology to avoid solvent use. C-I-L led members of the ICI group in Britain, West Germany and Australia in developing the product for commercial use.

But according to C-I-L officials, the company's participation wouldn't have been possible without the support of the IERD, which helps companies reduce the risk of developing more energy-efficient products and processes. Thanks to the program, there now exists a process that, with its reduced reliance on petroleum-based solvents, could provide an energy saving throughout the Canadian auto industry equivalent to 100 000 barrels of oil a year, with a superior finish and reduced solvent emissions.

"It has the potential of becoming standard, not only in Canada and the U.S., but also in Europe and Japan."

Charles Kaufmann
of C-I-L



Robots painting pickups in Oshawa.

Raising the Quality of Life from Coast to Coast

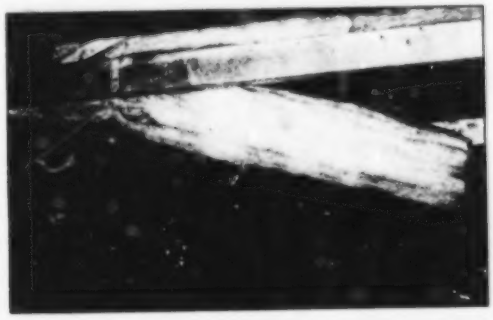
"If some countries have too much history, we have too much geography," said Mackenzie King. Whether it's possible to have too much of such a good thing is uncertain. But there's no doubt that geography has had a huge influence on Canada. It has governed our past, it shapes our present and it suggests our future.

An important part of that future will depend on how we use technology to respond to the geographical needs of our vast and varied country. Canada contains a number of distinct regions, each with its own technological history and requirements.

Recent efforts to build on this history, and to meet these special requirements, account for a significant part of our collective success. Coast-to-coast growth is now taking place at an unprecedented rate. In fact, during the last three years, Canada has enjoyed the fastest economic expansion of any OECD country.

Everybody can see the results of this development. But few people are aware of how it actually comes about, or of the key role the Energy R&D Program has played in fostering it.

"If some countries have too much history, we have too much geography."
Mackenzie King

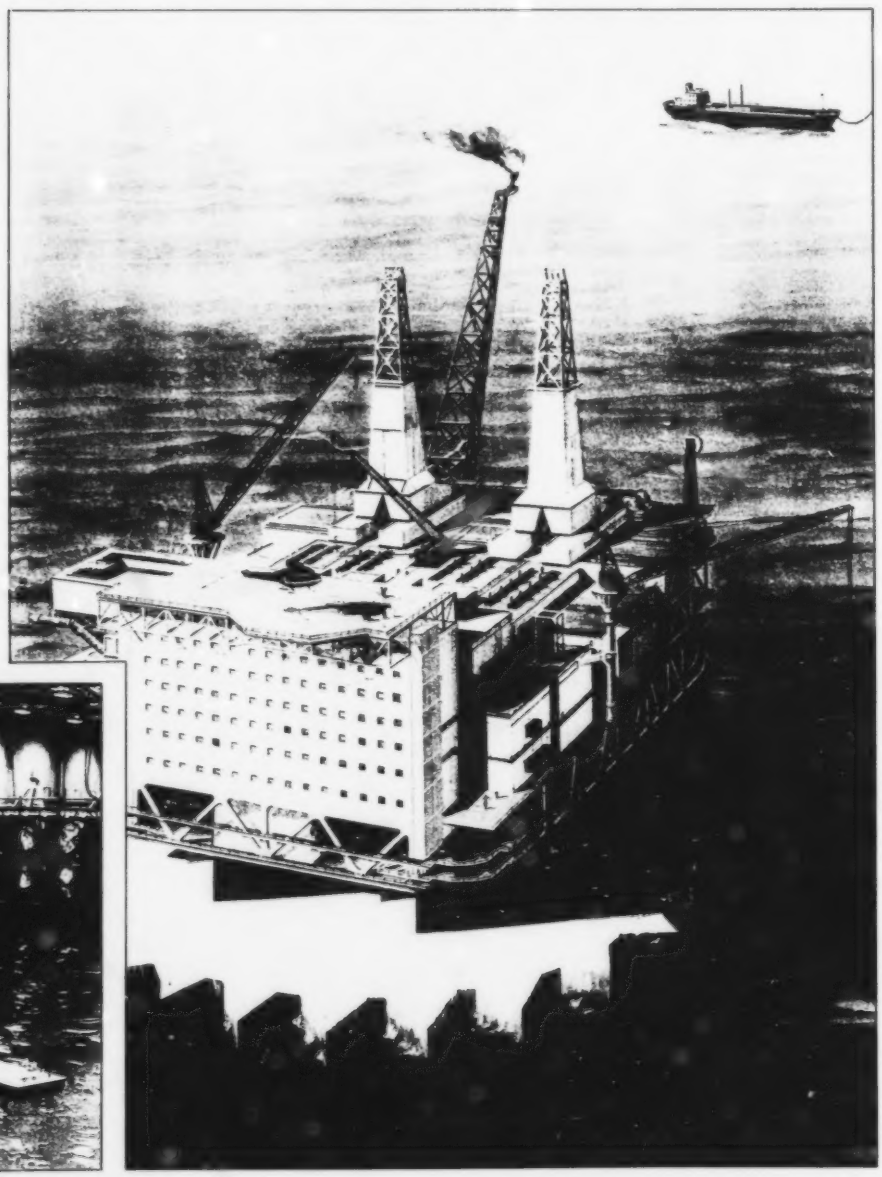


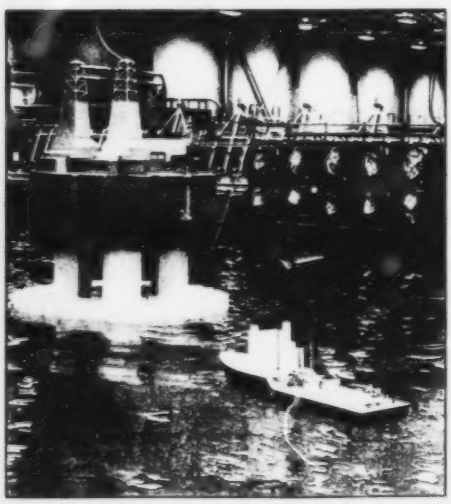
Evaluating foundations for service on permafrost in Arctic R-2000 homes, in Hay River, N.W.T.

Development of Hibernia Oil

Finding and recovering oil and gas is never easy—particularly in the stormy North Atlantic. But the Canadian Standards Association (CSA), with support from the Energy R&D Program, has reduced the risk of operating in this area. In cooperation with Canadian industry, CSA has developed material and structural codes for offshore oil rigs.

At the National Research Council, a multidirectional wave basin is used to estimate the effect of North Atlantic conditions on the Hibernia oil recovery structure. So severe are these conditions (high winds, heavy seas, icebergs) that the concrete portion of the actual structure will measure 105 metres in diameter and stand 85 metres high.





Simulating North Atlantic conditions in NRC's multidirectional wave basin.

Heat Pumps for Lobster Pounds

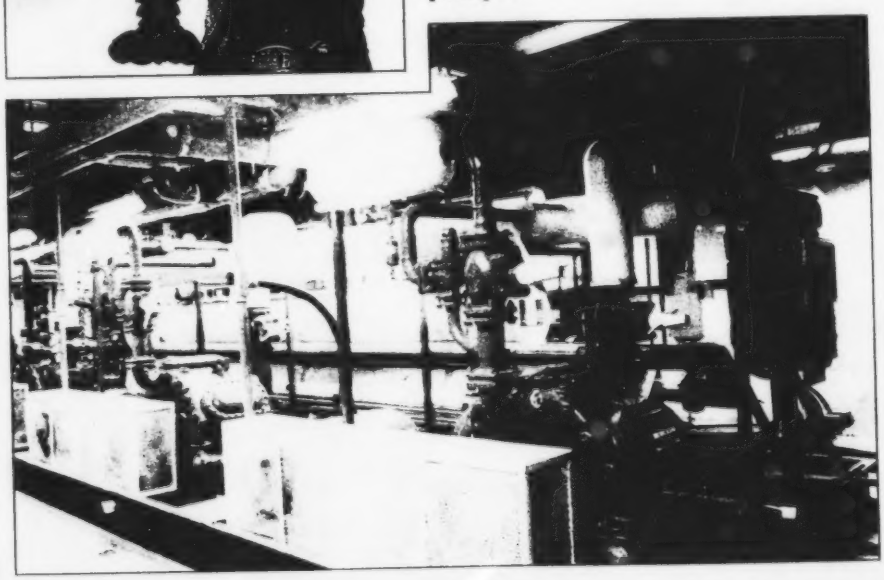
Clearwater Fine Foods, Ltd. is making it possible for lobster fanciers the world over to indulge their taste the year round. And satisfied customers are rewarding them with spectacular growth. But success didn't just drop into their pots. It required, in addition to the usual hard work, the timely application of two diverse technological developments.

Back in 1982 John Risley and Colin MacDonald, two entrepreneurs from Halifax, came up with one of their best ideas. They knew that if they could just find a way to keep live lobsters healthy in storage, they'd have all the overseas orders they could fill.

The Fisheries and Oceans Research Centre at St. Andrews, New Brunswick had shown that individual saltwater cages cooled to 4°C could spare a catch the damaging complications of lobster life at sea: storms, moulting provoked by warm water, and cannibalism. Risley and MacDonald decided to develop a land-based system, but the energy costs of cooling the circulating water appeared prohibitive.

John Risley approached the National Research Council with his problem. NRC, in association with J.H. Lock & Sons, a Halifax engineering company, had been developing industrial-scale heat-pump systems. These systems, Risley learned, could economically cool the lobsters *and* provide the heat needed for Clearwater's canning operation.

With the support of EMR's Industry Energy Research and Development program, Clearwater used the technologies from Fisheries and Oceans, NRC, and J.H. Lock to develop a process that keeps lobsters fit for European and Japanese markets throughout the year. As for J.H. Lock, the company has broadened its capability, and now designs and installs an extensive line of energy-efficient industrial heat pumps.



J. H. Lock heat pump at Clark's Harbour, N. S.

As a result of this initiative, Clearwater has been able to make a previously seasonal business pay the year round, secure its overseas markets, and acquire a dozen companies in North America and the United Kingdom, raising full-time employment to more than 3200 people.

"Without the program we wouldn't be in business today."

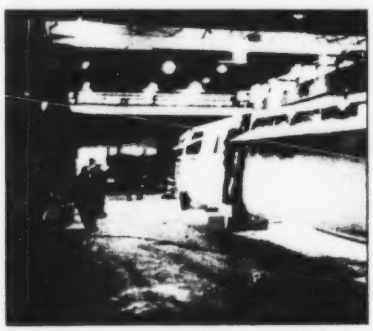
John Risley

EOLE Wind Turbine

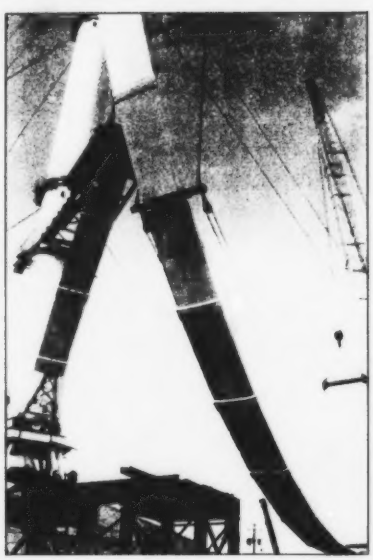
Project EOLE, situated in Cap-Chat, Quebec, is the largest vertical-axis wind turbine in the world. EOLE has further demonstrated the practicality of renewable energy solutions, advanced the state of the art in wind energy technology, and confirmed Canada's international leadership in the field.

Although EOLE will supply only a small fraction of Quebec's electricity needs, it has broadened the options for regions of limited energy resources and played an important part in the development of complex aluminum alloy extrusions. The project has brought about one industrial spinoff already: collaboration between Lavalintech Inc., the owner and operator of EOLE, and Dornier System G.m.b.H., in West Germany. The success of the project has also sparked proposals for cooperative efforts from West Germany, the United Kingdom and the United States.

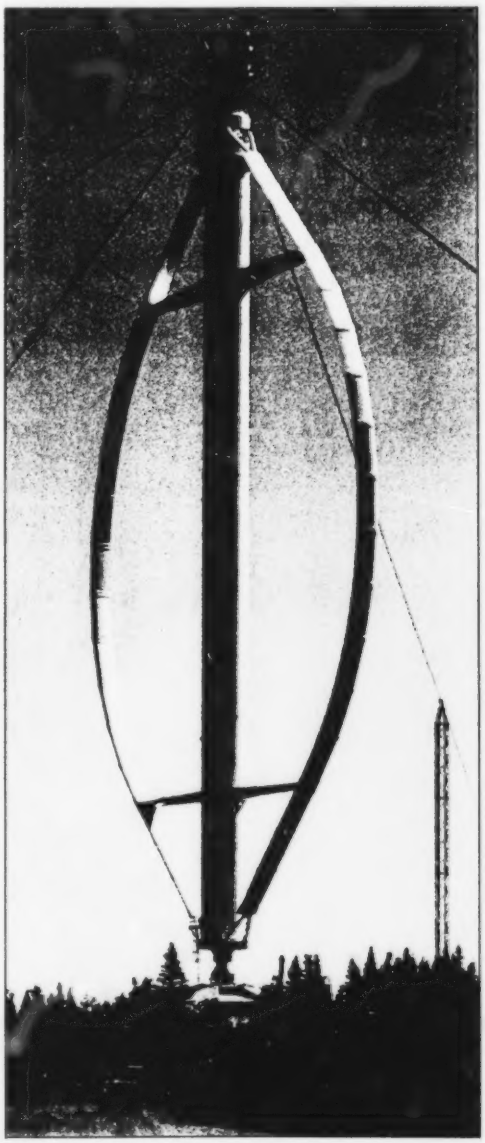
Using funds from the federal Energy R&D Program, construction and design costs for EOLE were shared between Hydro-Québec and the National Research Council.



Manufacturing EOLE components at Versatile Vickers Inc. in Montreal.

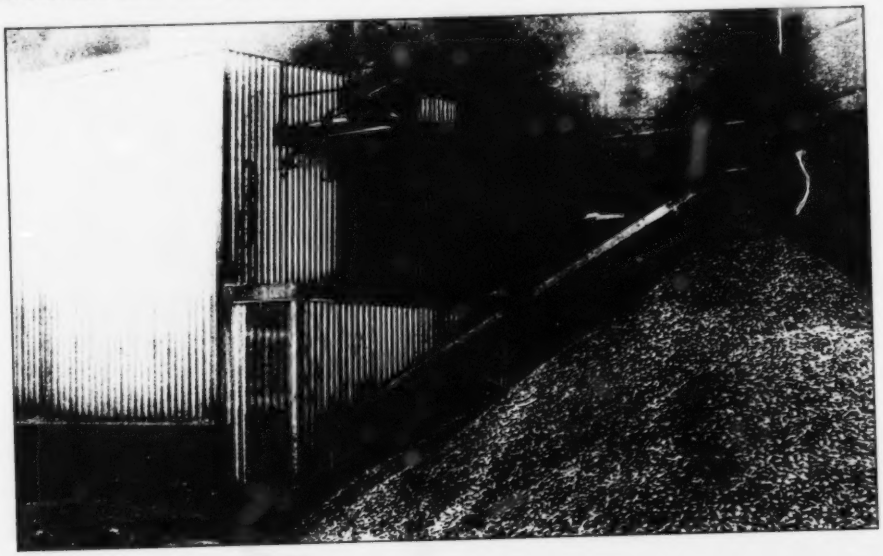


Erecting sections of the rotor blades at Cap-Chat.



Phosphoric Waste to Furnace Fuel

In Varennes, Quebec, Erco Industries has recently achieved what it calls a 'fantastic breakthrough'. It's a process that briquettes otherwise unusable waste from the manufacture of elemental phosphorus, thus providing feed for the company's electric furnaces. Besides saving large amounts of energy, this process decreases dependency on imported materials and reduces the difficulties of waste disposal.



Greenhouse Development at Chicoutimi

Fresh local produce in the North all year round? It's looking more likely all the time. Using waste heat from Union Carbide Canada Limited's selenium smelter, Agriculture Canada's greenhouse technology for northern climates has brought winter vegetable production to Chicoutimi, Quebec. The department has published descriptions of this technology and expects wide use of it in the future.

Electric Motors

Motor design at GE Canada had been advancing slowly for some 25 years when, in the late seventies, the company suddenly found its established markets in jeopardy. Having become familiar with innovations from Europe and Japan, customers were demanding a product with more power, efficiency and durability. By 1980 GE Canada had begun to lose Ontario Hydro contracts to foreign companies. Eight hundred Canadian jobs were at stake.

It was time to move quickly. But though the company had the technical expertise to get the job done, resources for high-risk development were limited.

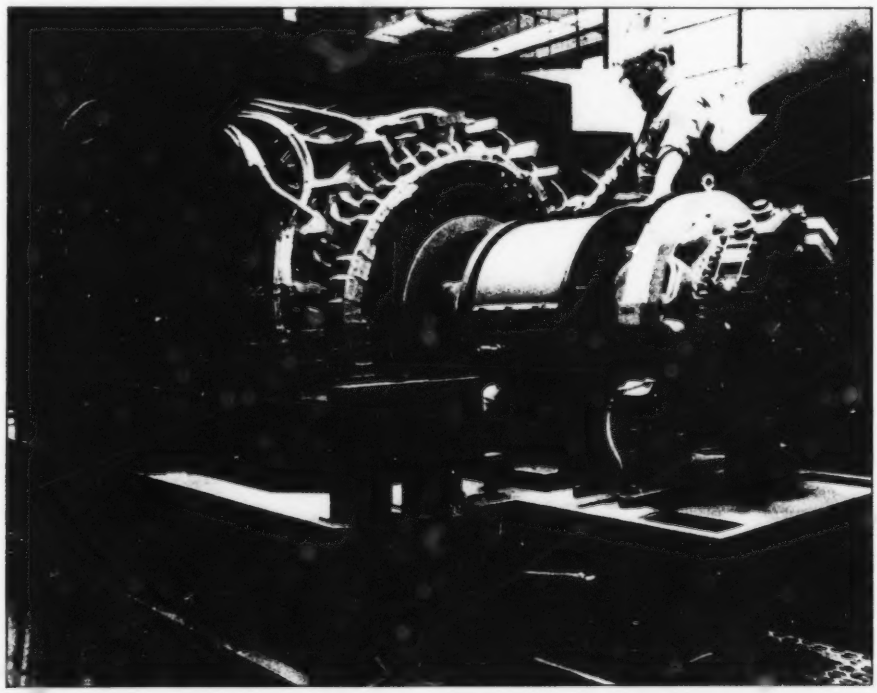
At this point GE Canada turned to the Industry Energy R&D Program. And the tide soon began to turn. After studying GE Canada's plan of action, Ottawa decided to contribute 45% of motor development costs, thereby reducing the company's risk to an acceptable level. GE Canada, as a condition of assistance, agreed to put the technology directly into effect if the development plan proved successful.

The plan has since succeeded beyond preliminary expectations, resulting in, among other developments, high-efficiency synchronous and induction motors of 500 to 50 000 horsepower. All such GE Canada motors with stator core diameters of greater than 1.5 metres are now the responsibility of the company's Peterborough plant. Having many heavy-machinery applications (ships, pumps, compressors), they are expected to bring GE increased sales throughout the world.

"One of the keys to the survival of our business."

Andrew Archer, manager of motor development at GE Canada

Thus the Energy Program, by its willingness to share some of the risk involved in R&D, allowed an important section of GE Canada to reduce energy costs for its customers, reinforcing some 800 jobs in Ontario, and brightening the prospects of Canadian electric-motor manufacturing everywhere.



Six-thousand-horsepower AC synchronous motor, manufactured at GE Canada's Peterborough plant.

Grain Drying

One important area in which energy has lately been used to greater effect is grain drying, a major cost on many Canadian farms. Instead of drying only during very wet harvest seasons, many prairie farmers now use drying as part of their normal grain-harvesting system. Drying can extend the harvest season, reduce field losses and, by eliminating storehouse spoilage, increase grain quality.

The Energy R&D Program, through Agriculture Canada, has supported several improved grain-drying systems. One of these, developed by the Prairie Agricultural Machinery Institute, employed hot-air and natural-air methods in combination. Besides using substantially less energy than simple hot air, the combined process maintains a higher grade of grain.

Equipment Monitoring

Another field of research that will benefit Canadian farmers is the development of control and monitoring equipment. Fuel consumption on farms has a major effect on production costs. Even a small improvement in the efficiency of operation can mean several hundred dollars a year to a farmer, and millions to Canadian agriculture.

Because of carefully selected projects supported by the Energy R&D Program, investment dollars generated by energy savings are now working to improve agriculture throughout Canada. In one of these projects, the University of Manitoba's Department of Agricultural Engineering developed a microwave Doppler radar to measure one of the main sources of heavy-equipment energy loss: wheel slip in tractors. The work proved to be practical, and similar technology is now available as a factory option on many tractors.

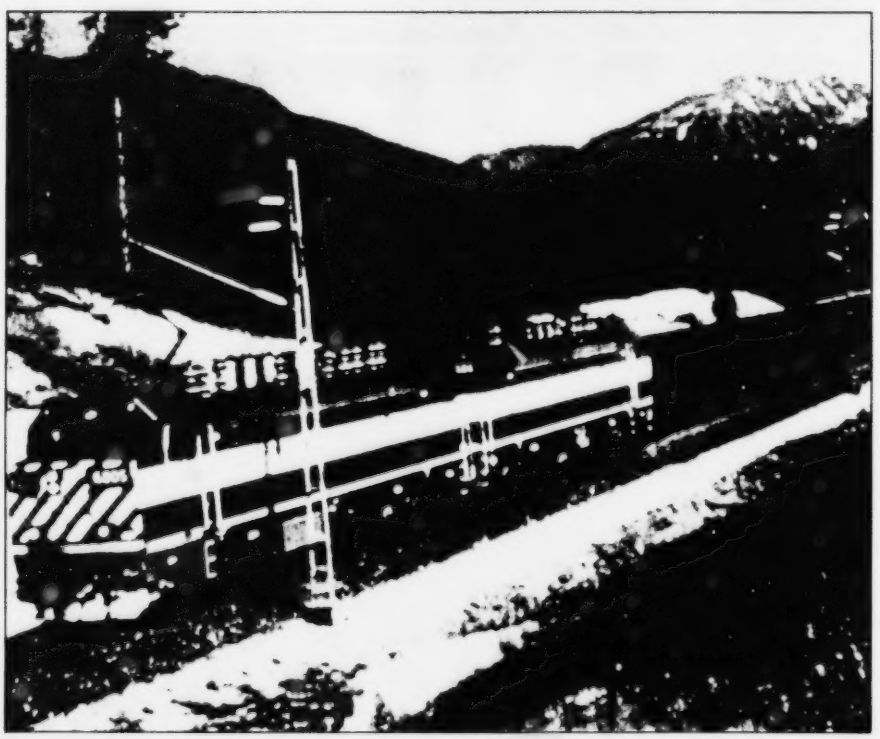
Apparatus for evaluation of tractor fuel efficiency meter.
Fuel efficiency meters are now available as a factory option on some tractors.

Railroad Electrification: Tumbler Ridge, B.C.

Between 1981 and 1983, BC Rail built the Tumbler Ridge Branch Line, the first 50-kV electrified railroad in Canada. The 130-km line provides rail access to the northeastern coalfields of British Columbia. Carrying coal destined for Pacific Rim markets to a new deep-sea export terminal at Ridley Island near Prince Rupert, the new line enables the province to keep pace with the growing demand for its high-grade metallurgical coal. The federal Energy R&D Program, through Transport Canada and various electrical component industries, supported the development of the systems and new products used in this construction.

BC Rail decided to develop the electrified system for two basic reasons. First, the 50-kV electric system provides greater hauling power on steep grades, thus allowing the 100-car unit coal trains to operate more efficiently in the mountainous terrain, saving up to 50% in energy costs, and reducing maintenance costs by more than 60%. Second, electrification eliminates both the cost of ventilating the line's 15-km tunnels and the danger diesel emissions pose to the delicate mountain ecosystem.

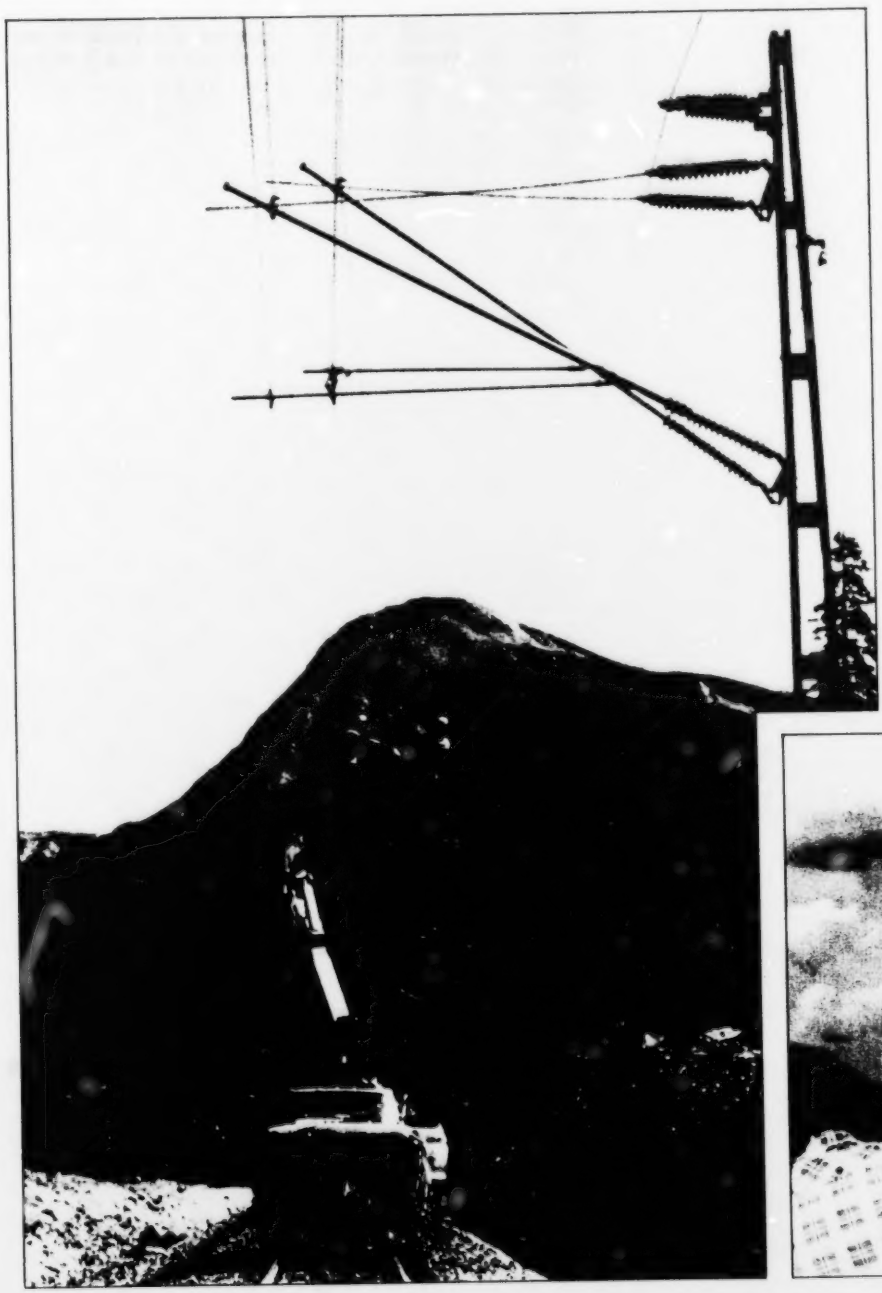
Fifty-kilovolt engine from General Motors of Canada Limited.



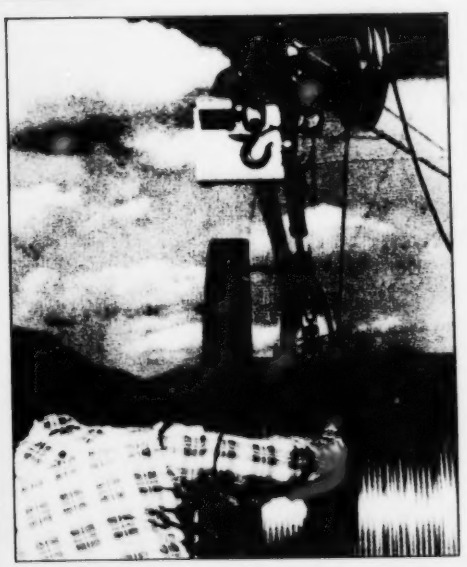
One-hundred-car coal train, Tumbler Ridge to Anzac line.

Railroad Electrification: Tumbler Ridge, B.C.

Throughout this project, BC Rail made extensive use of Canadian technology, while importing the best available foreign technology and adapting it to local conditions. BC Rail's development efforts, together with those coordinated by the Transportation Development Centre in Montreal, have generated a major industrial capability that not only provides options for further electrification of Canadian railroads but also broadens our copper markets.



Erecting the conductors on the 50-kV line.



Arctic Navigation

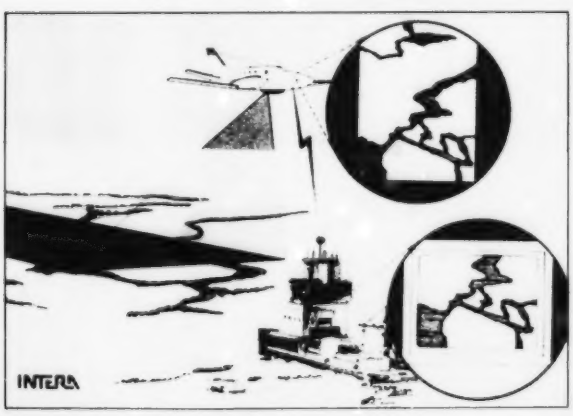
The Far North, with its hard weather and rough terrain, has never lent itself to easy travel. And Arctic navigation is still hindered by the year-round presence of ice (which is both a physical hazard and a cause of excessive fuel costs) and the lack of comprehensive maps and charts. Recently, however, the federal Energy R&D Program has funded work by Transport Canada, Fisheries and Oceans and Canadian companies that has improved charting and ice detection in Arctic waters, thereby raising the level of safety and reducing energy consumption in the shipping industry.

Extensive hydrographic surveys are now recording the details of shoreline, seabed, tide and ocean current characteristics in previously uncharted Arctic seas. Owing to new tools that allow depth measurement through ice and more reliable remote-data gathering, many of the old climatic and geographical obstacles have been overcome.

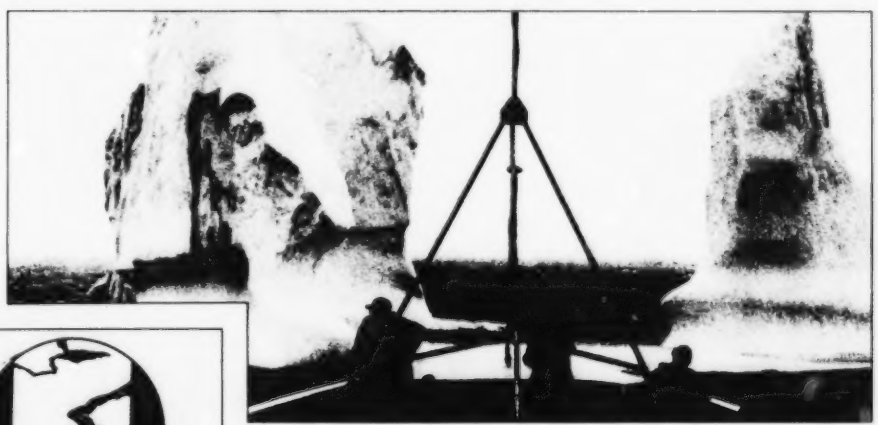
In addition, the use of advanced remote-sensing techniques and new computer systems are increasing the quality of information available to ships sailing through Arctic waters. Satellite-based radio beacons have made ship-positioning systems more accurate, and satellite data are helping to route ships through pack ice.

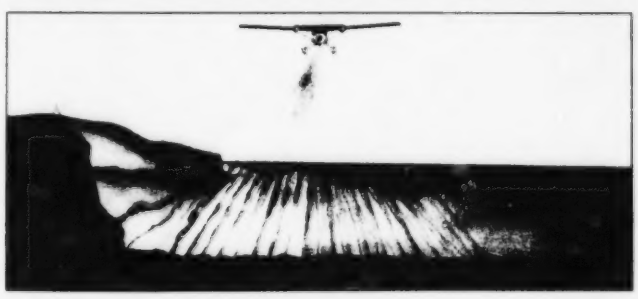
These developments will improve the transportation of construction materials and supplies to the North, while facilitating the shipment of minerals, oil and gas from the High Arctic islands and the Beaufort Sea. Projects such as Bent Horn, the Beaufort Sea and Polaris are all made possible by this work. The tanker MV *Arctic* has just been recommissioned with synthetic aperture radar (SAR) ice detection systems, which will add to its capabilities of operating in ice-infested waters.

Diagram illustrating synthetic aperture radar systems (SAR) for optimum course selection through ice fields.



Airborne LIDAR based on the use of laser beams for detailed and more rapid charting.



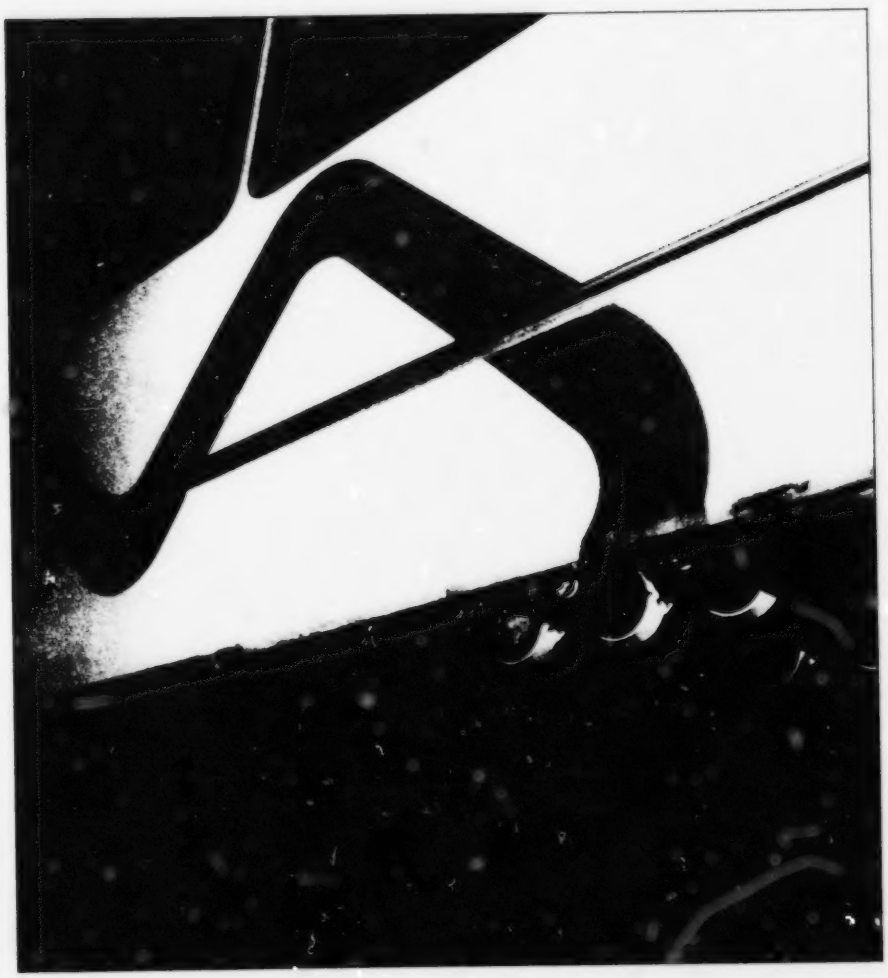


Making the Most of Our Resources

Blessed with an abundant resource base, Canada has developed very energy-intensive industries and habits of life. Some people see this as a cause for gloom. But a closer look reveals an exceptional opportunity.

Where other nations must concentrate on acquiring access to resources they do not have, our circumstances permit us to devote a good deal of effort towards putting what we have to better use. Canada is now in a position to improve its industrial competitiveness, increase the availability of energy for domestic and export use, reduce the risk of environmental damage and save its citizens a lot of money—all through the adoption of energy-efficiency measures.

Energy efficiency means getting more out of the energy we use, not merely using less. For this reason, our ability to adopt fruitful energy-efficiency measures is directly dependent on R&D. Much of our research and development in energy efficiency has been carried out or made possible by the federal Energy R&D Program, often through cost-shared work with the private sector. Owing to these efforts, we have been able to develop new technologies and appropriate standards, many of which are being successfully applied throughout Canada.



Capturing braking energy with hydraulic accumulators on a Mississauga bus. This saves fuel and reduces engine emissions.

Conserval Wall

In 1986 Conserval Engineering of Downsview, Ontario, with support from the federal Energy R&D Program, completed development of the technology for Canada's largest solar air heating system at Ford's Oakville assembly plant, an installation that comprised 1858 square metres of collector panels.

Large factories are not easy to heat. Manufacturing processes often remove air from the building, creating negative air pressure. Cold air comes through cracks in windows, doors and walls. Hot air rises and is forced out. Result: cold, drafty conditions for employees.

At the Oakville plant, which covers some 200 000 square metres of floor space and has an average ceiling height of 5.4 metres, ceiling temperatures were often 10 degrees above those on the floor.

Such problems have been handily solved by the Conserval system. Fresh air is trapped between two layers built into the south-facing walls. Solar heat warms the air, which is then fanned into the building and distributed by ducts mounted along the ceiling. The continuous supply of outside air offsets negative pressure, regularizes inside temperatures and improves air quality.

Upon studying reports on the Oakville plant, experts at the International Energy Agency's workshop on air heating held in Utrecht, the Netherlands, declared the installation to be one of the most successful retrofit solar heating systems they had seen.

Heating the Ford plant at Oakville with solar energy.

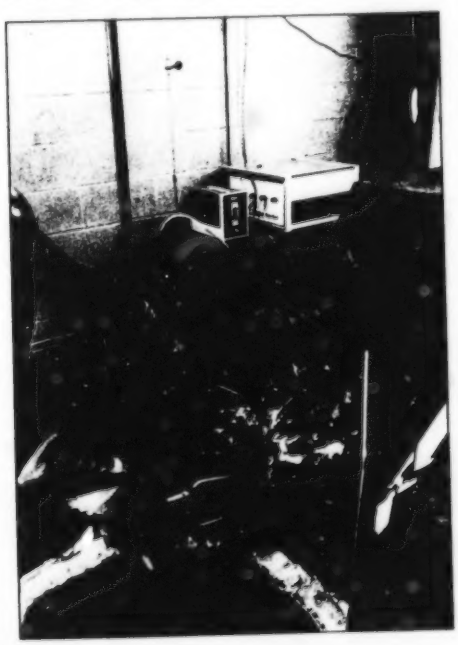
Residential Housing

The Canadian construction industry and the federal government have developed a new, higher quality kind of housing: the R-2000 home. Designed to increase comfort while cutting heating costs by up to 70%, the R-2000 program brings more than a decade of government-sponsored research to the Canadian market. And related products developed under the EMR-managed program have begun to provide opportunities for Canadian companies. These products include improved domestic furnaces and water heaters, equipment to measure air infiltration in buildings, and ground-source heat pumps

An R-2000 house is about *two-thirds* cheaper to heat than a conventional house of comparable size. This remarkable improvement is the result of highly skilled teams of builders applying airtight construction and a continuous air-vapour barrier, doubly efficient insulation, heat-recovery ventilation systems, and double- or triple-glazed windows.

The R-2000 home: *two-thirds* cheaper to heat than a conventional house

Based on work carried out under severe prairie conditions by the National Research Council's Division of Building Research in Saskatoon, and corroborated by further developments at Canada Mortgage and Housing Corporation and NRC's Ottawa laboratories, EMR decided to undertake the R-2000 project in collaboration with the Canadian Home Builders' Association. There are now some 300 builders in the program; the goal is to raise that to 2500 by 1991. Not all Canadian houses are built to these high standards; but owing to the influence of R-2000, today's builders are producing more efficient and comfortable homes.



The R-2000 project, the energy-efficiency R&D at NRC and CMHC, and the combustion and furnace developments in EMR's CANMET laboratories have been a major factor in expanding the technology base in all aspects of Canadian residential buildings. Despite the adverse winter climate in many parts of the country, home heating costs in Canada are no greater than in many European countries with much warmer winters.

Developing furnace control systems at CANMET for new heating oils produced from tar sands.

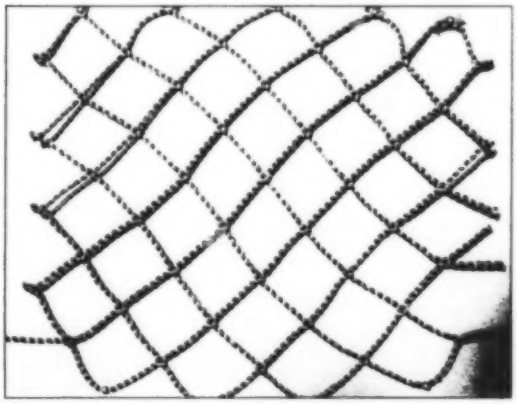
Assessing wood stove efficiency at CANMET.

Increased Efficiency in the Commercial Fishing Fleet

A new knotless fish net has been found to reduce fuel costs, improve fish quality and vessel safety, and aid in the conservation of undersized fish.

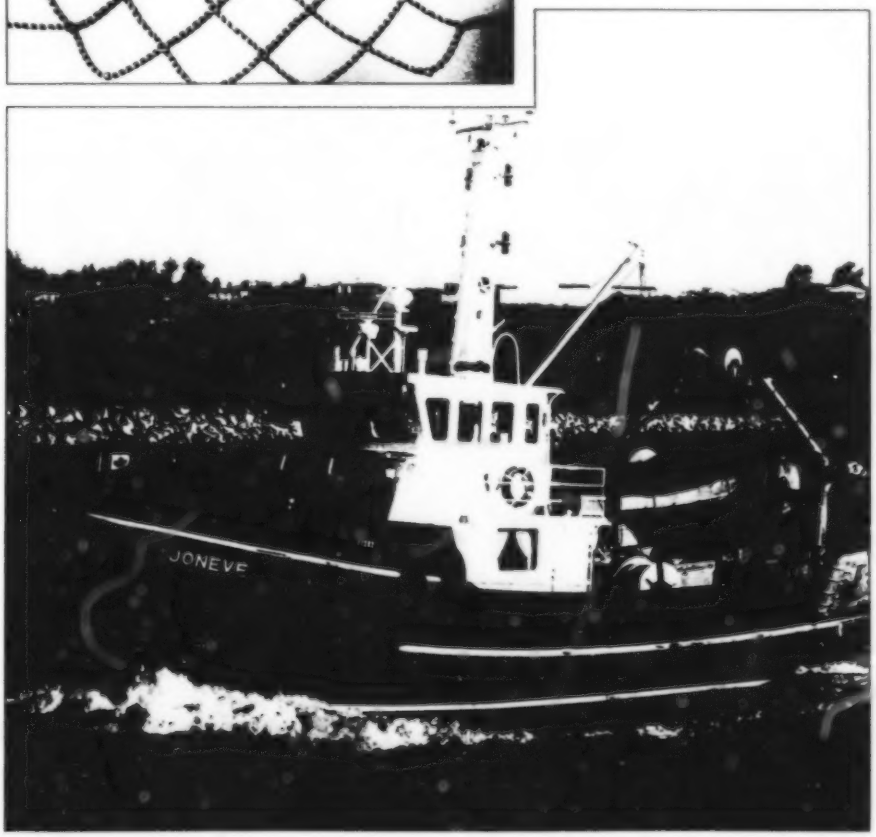
This project originated at Scantec of Nova Scotia, and was supported by the Department of Supply and Services' unsolicited proposals program and by energy R&D funding from Fisheries and Oceans. Following laboratory trials, sea trials were conducted off Paspébiac on the Gaspé Peninsula. Captain Chevarie, a Gaspé fisherman, immediately bought one of the new nets.

"It works exactly as the experiments showed," said the captain one month later. "It's lighter, takes up less room on the net reel, and so helps keep the boat more stable in rough seas. It's also easier to handle and to tow; and when it's damaged, it doesn't tear as badly."



Knotless fish net.

In addition to saving energy, the new net assists in fish conservation by allowing undersized fish to escape more easily. Captain Chevarie found that "less than 1% were retained in the new net, compared with 20% in the normal knotted trawl."



Captain Chevarie's Joneve setting out from Paspébiac.

This new system could result in fuel savings of $3 million a year.

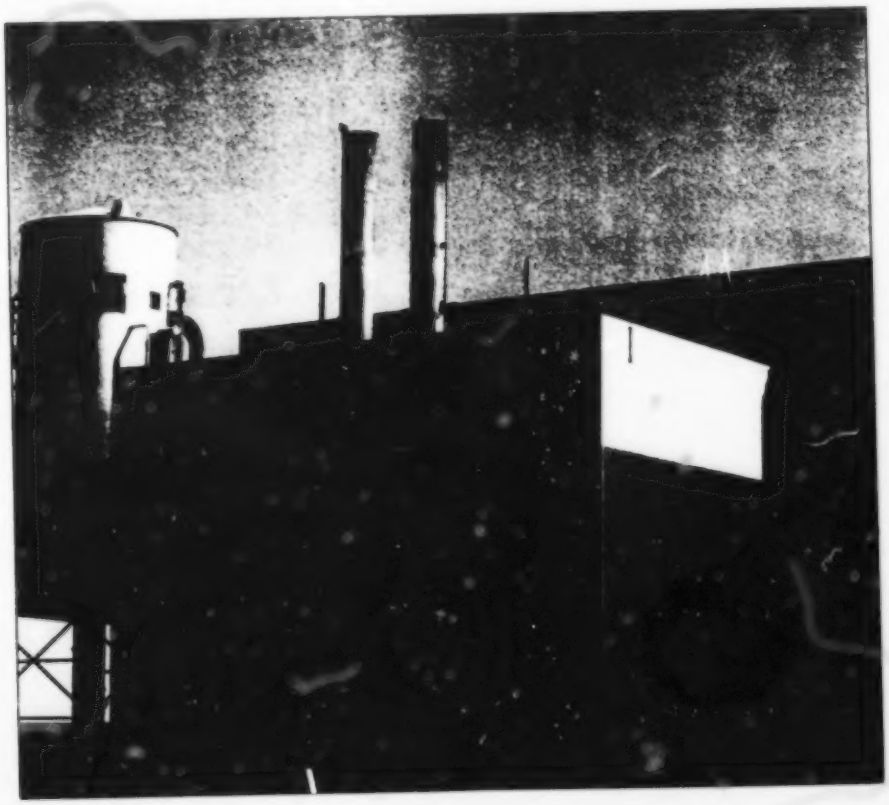
Fluidized Bed Combustion Systems

The fluidized bed combustion system (FBC) is a technique that promises increased efficiency with substantially lower furnace emissions of sulphur and nitrogen oxides in the airborne effluents that cause acid rain.

An FBC unit burns coal (or other fuels) in a bed of hot inert particles suspended, or 'fluidized', by air currents. Within this turbulent bed, coal particles are burned. In order to prevent release of sulphur dioxide into the atmosphere, noncombustible solid particles such as limestone are added to the bed to absorb the acidic gases. As for nitrogen oxides, this common pollutant from coal combustion is controlled by the FBC boiler's air-flow conditions.

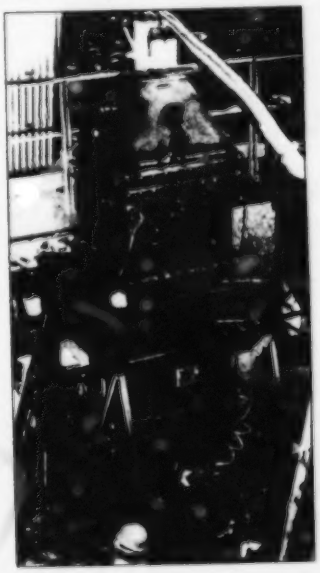
But FBC technology is not just easy on the environment; it also eliminates waste. FBC boilers may also be able to use many currently noncommercial and low-grade fuels (coal washery wastes, high-sulphur coals), as well as hard-to-burn materials such as coke produced as a byproduct of oil-sands refining.

Canada is sharing its experience in this field with its partners in the International Energy Agency, and extensive fluidized bed combustion projects are underway throughout the world. Since much of the work must be done in large and expensive pilot plants, the current rate of development has been possible only through collaboration. Much of the engineering data needed for the design of new combustion furnaces has already been developed, and soon another energy option based on coal should be at our disposal.



New Brunswick Electric Power Commission's fluidized bed facility.

Fluidized bed pilot plant at the Canada Centre for Mineral and Energy Technology (CANMET).



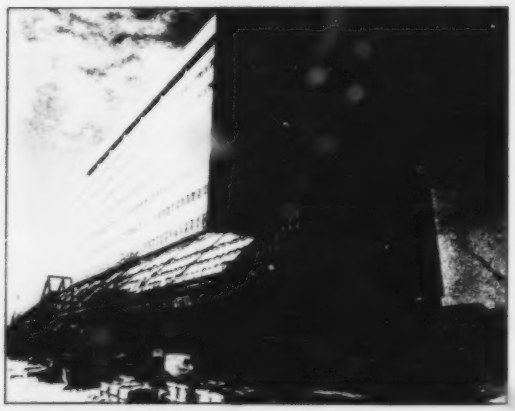
Energy Storage

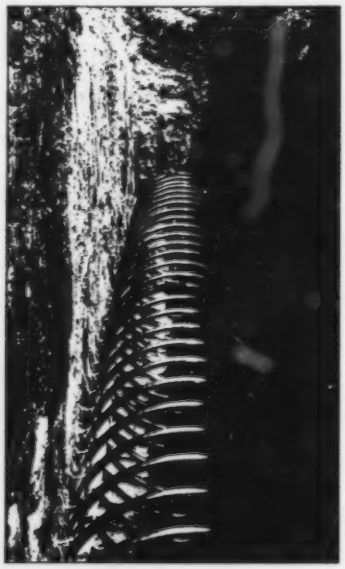
Energy storage is nothing new to Canadians. Saving winter ice for summer use was customary for generations. Lately, however, the Energy R&D Program has been working on newer, more efficient variations on this concept. In one of the most important of these variations, heat pumps are used to keep buildings warm in winter and cool in summer.

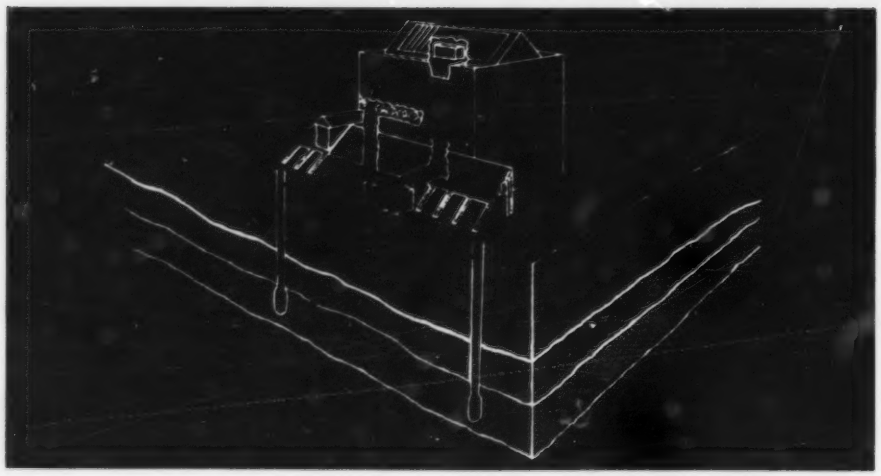
The heat pump in the Scarborough Canada Centre Building, for instance, pulls winter heat stored in the course of summer cooling from an aquifer 50 metres below ground. This system, which was developed by Public Works Canada, has now been operating successfully for more than two years.

There has also been a breakthrough in equipment for residential and commercial ground-source heat pumps: a copper heat exchanger built in a vertical spiral. Developed at the National Research Council, this exchanger provides very high heat extraction rates, and is only one third the size of its competitors.

Though not normally recognized as such, these developments are actually a form of solar heating. Ground-source heat pumps recover solar energy previously absorbed by the earth.







Federal Scarborough Canada Centre Building, heated and cooled by heat pumps using natural water from below the ground.

Copper spiral heat exchangers improve energy efficiency for ground-source heat pumps.

Reducing the Risk in Technology-Based Innovation

Once an industry stops growing, it doesn't usually have long to live. Thus survival dictates that industries be constantly on the alert for new growth opportunities.

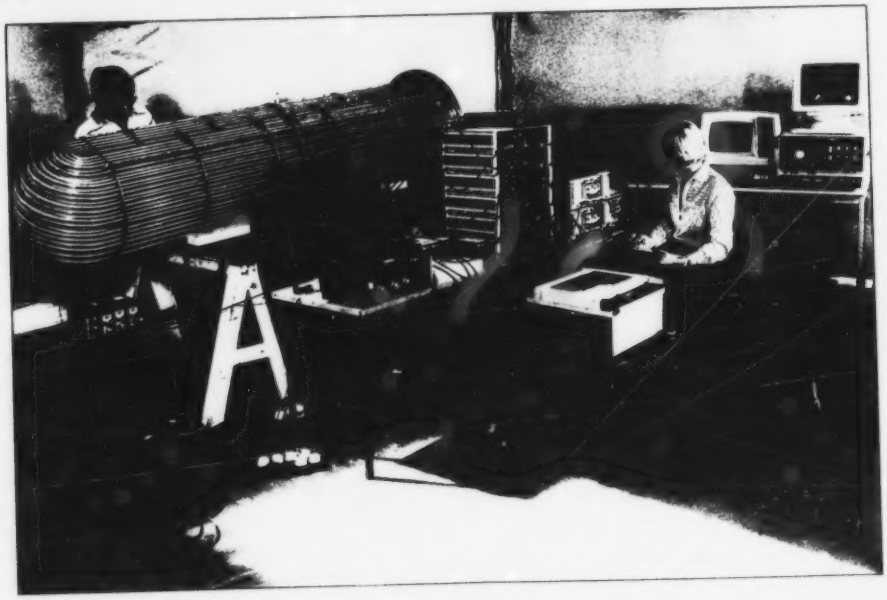
These new growth opportunities—and the new public needs that provide them—are frequently generated by technological innovation in the use and acquisition of energy. In fact, such innovation so determines the range, quality and price of goods and services that no industry can afford not to keep abreast of relevant technical developments in this field.

It's not always easy, however, to stay on the cutting edge. As technologies grow ever more complex and expensive, they make increasingly greater demands on capital and human resources. In a modestly populated country like Canada, it is necessary to maintain access to foreign developments, to build institutions capable of concentrating resources to maximum advantage, and to choose R&D projects with the utmost care.

Helping to meet this challenge is the federal Energy R&D Program, which serves Canadian industry by providing it with specialized R&D, energy resource evaluation, financial assistance to reduce risk in development projects, expert advice, and opportunities for international and intercorporate cooperation.

Heat Transfer and Fluid Flow Service

Heat-transfer and fluid-flow technology lie behind all uses of energy, and technological development in this field provides industry with confidence in design, improved operating liability, reduced equipment costs, and energy savings. The Heat Transfer and Fluid Flow Service, with funding from Canada's Energy R&D Program and the U. K.'s Department of Trade and Industry, performs research on and transfers technology for the design of heat-transfer and fluid-flow equipment (heat exchangers, boilers, condensers, flow control systems) for the process industries.



Preparing new exchangers to evaluate design changes.

Mobile Foundry Laboratory

The Mobile Foundry Laboratory (MFL) has put the results of R&D into the hands of foundry workers, enabling them to solve many of the problems that threatened their economic survival in this extremely energy-intensive industry.

Early in 1983 the Canadian foundry industry was in trouble. Rocked by the recession of the early '80s, squeezed by foreign competition, hampered by obsolescent technology, many foundries were suffering severe encroachments on their former market share.

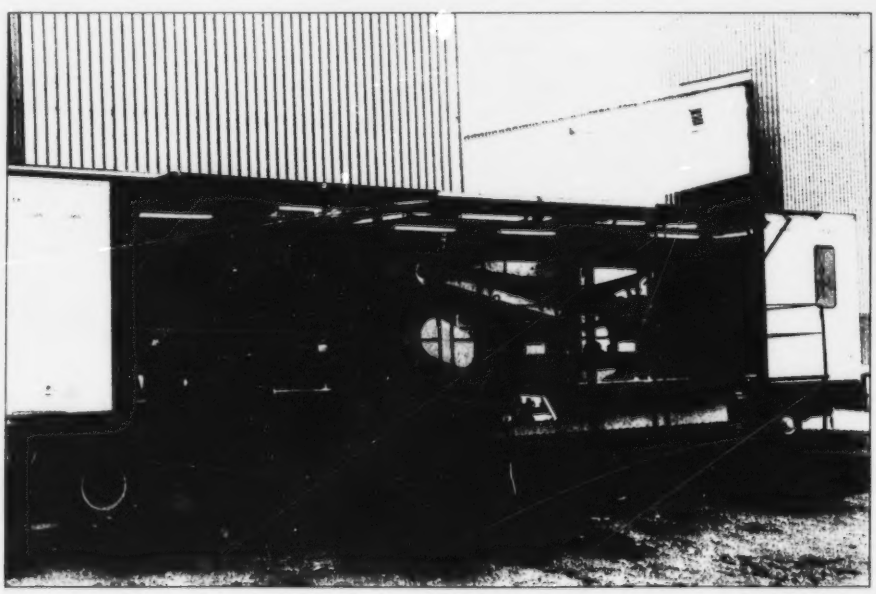
To provide these companies with the know-how to take advantage of existing opportunities, the Canada Centre for Mineral and Energy Technology (CANMET), with Energy R&D support, organized MFL teams to deliver on-site instruction from a specially equipped tractor-trailer laboratory.

During the next two years, the MFL visited 76 of the smaller foundries, and traveled some 15 000 kilometres. Afterwards, an independent survey pronounced the project a huge success. The 41 companies audited in the sample estimated savings of over $6 million in six years. During the next 11 years, based on the sample, the entire industry figures to save some $40 million. And perhaps most interesting, it was discovered that a more profitable foundry industry could bring the government nearly $11 million in additional taxes from an investment of only $1.44 million.

Of course, money figures don't mean much apart from human ones. And there were improvements in this area as well: projections indicated that 138 jobs would be created throughout the industry.

Nearly $11 million in additional taxes from an investment of only $1.44 million

Sample foundries were very receptive to the MFL recommendations. That means that much of the industry will soon be using the new technology to make better products and reduce fuel costs. And it means that a considerable number of companies have come to realize the many ways in which development work can solve problems and increase profits.



CANMET's mobile foundry.

The ABCO Food Blancher

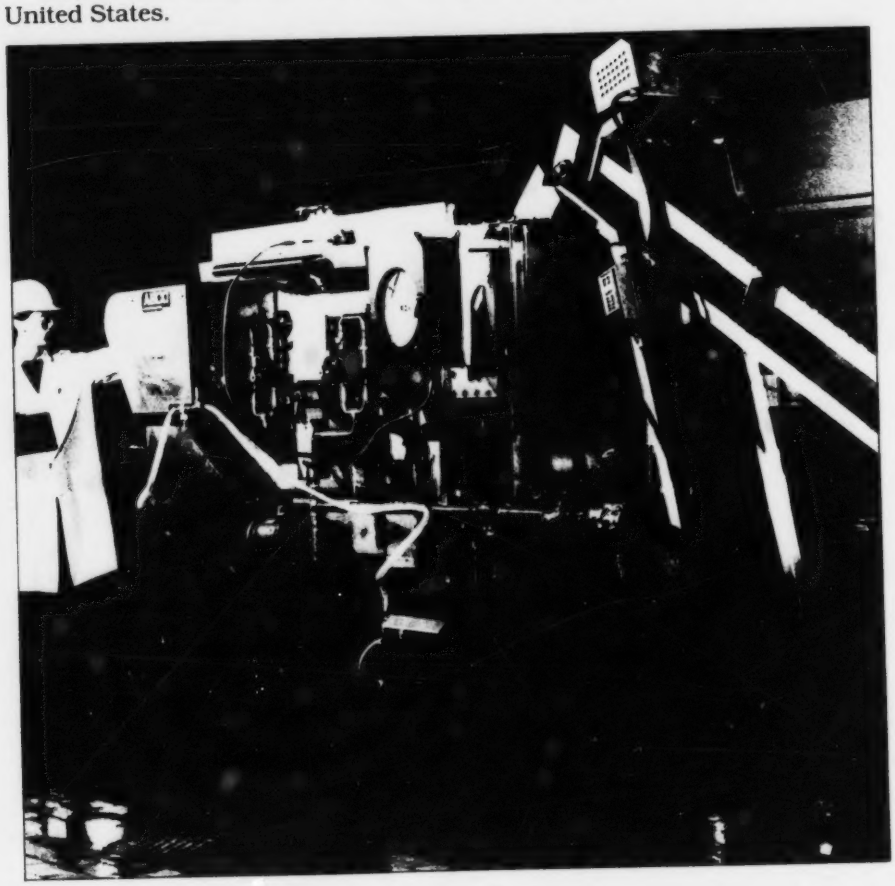
Agriculture Canada's Ottawa engineering laboratories have helped to develop a new food processing system that not only produces higher quality frozen vegetables but also cuts energy costs in processing by 80%.

Steam blanching (heating vegetables until their natural enzymes are deactivated) is an essential step in preparing fresh vegetables for freezing. It allows prolonged storage of good-quality frozen products. But conventional blanching equipment, which uses steam or heated water, is very energy intensive; and the products are often 'overblanched', causing a loss in flavour.

After test results at Agriculture Canada's Kentville, Nova Scotia centre suggested that a new type of blancher might have commercial potential, the department made a cooperative agreement with the Atlantic Bridge Company Ltd. (ABCO) of Lunenburg to manufacture and market the product.

In commercial production since 1980, the ABCO blancher has gained wide recognition in the food processing industry. The machine received an honours award from *Food Processing*, the industry's journal, that judged the ABCO blancher to be a "major contributor to more efficient and effective operations in the food processing industry".

ABCO food blanchers are now being sold throughout Canada and the United States.



ABCO blancher preparing vegetables for freezing.

Maximizing Our Options

Since the early '70s, most industrial countries have been attempting to diversify their energy supplies and reduce dependence on oil, particularly imported oil. Some have been successful, but recent lower energy prices have made this target difficult to achieve. Although Canada is fortunate in the diversity of its energy resources, our goal is the same as that of the other members of the International Energy Agency: to ensure reliable supplies of energy. To achieve this goal, we must develop new options and a capability to adapt to possible changes in the patterns of energy supply, demand and distribution.

This means two things: developing new kinds of energy, and making more efficient use of the energy resources now at our disposal. And both of these require technological innovation and implementation in the context of a vibrant, flexible economy.

The Energy R&D Program, through its participating departments, and in cooperation with international agencies, private industry and the universities, works for Canada's energy diversity in several ways.

First, it ensures, through its own research and development, that the government has the technical knowledge required to discharge its energy policy, along with its regulatory and jurisdictional responsibilities.

Second, the program works to increase energy choices for Canadians and to provide environmentally and economically viable alternatives to conventional energy sources.

Third, the Energy R&D Program lays the technical and regulatory foundation for potential transitions to alternative energy sources in the coming century.

Finally, the program complements industry by providing the technological support for maintaining security in domestic energy supplies.

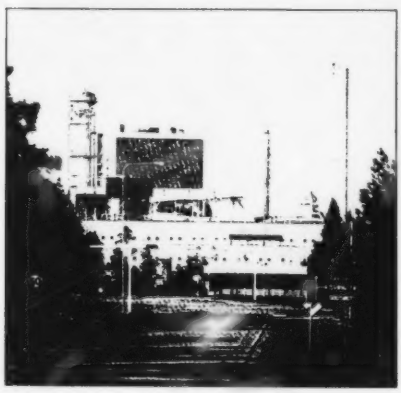
Project MILE

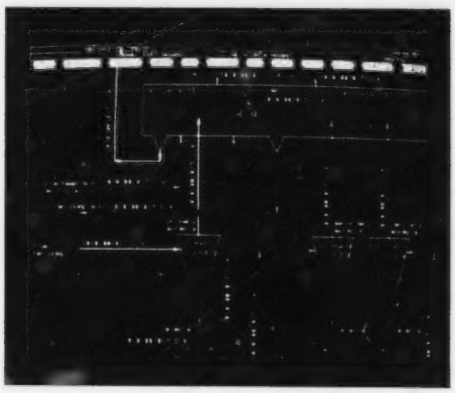
Methanol is a promising alternative fuel for bus and truck fleets. It can be stored and transported in much the same way as conventional fuels, and it reduces some of the noxious emissions from gasoline and diesel trucks. Project MILE (Methanol in Large Engines) represents the first comprehensive trials in the use of methanol in larger engines. The Medicine Hat bus system is now comparing methanol with conventional fuels.

SACDA

Because large energy and process systems are generally run at less than optimum performance, process engineers and plant managers are continually seeking ways to increase efficiency. In this search, process simulation provides a very practical tool.

SACDA, established at the Engineering Science Faculty at the University of Western Ontario, has grown into one of the Canadian leaders in the field. Its research into the development and use of simulation models—which include energy and materials, capital utilization and engineering time—has been supported by the Energy R&D Program as well as the Department of Regional and Industrial Expansion. Now operating in the private sector with offices in Chicago, Montreal, and London, Ontario, SACDA has improved the efficiency of several other industries: its simulation models are used for design, operation and training in pulp and paper, chemicals and mining.

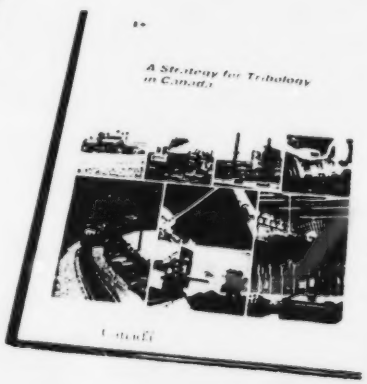




This Swedish paper mill bought SACDA models to optimize its energy management.

Tribology Opportunities

Tribology (the science of friction and wear) has given us a whole new direction in energy savings. Studies show that friction and wear cost Canada more than $5 billion a year, $1.3 billion of which could be saved through either new technology or better use of the technology we already have.



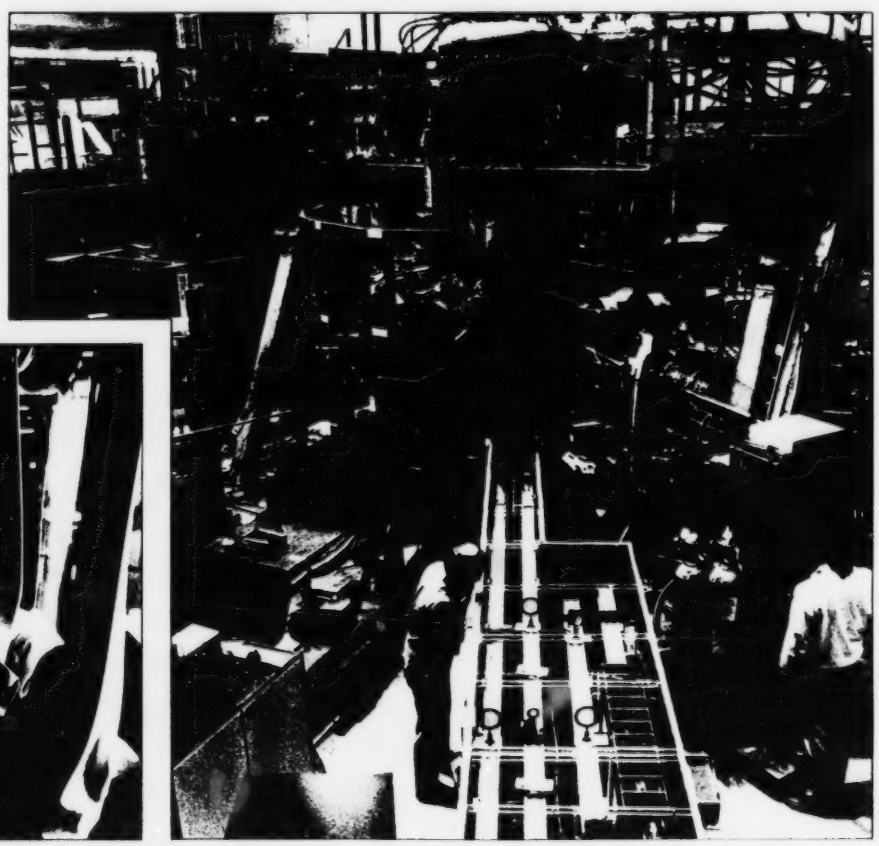
Through the Energy R&D Program, losses caused by friction and wear have been assessed, and a strategy to limit these losses has been developed. This strategy, which affects products as diverse as ploughs and Canadarm, was developed by the National Research Council and a wide group of Canadian companies. It links all sectors of the Canadian economy.

Fusion

The atoms from which all matter is made are potentially the source of large amounts of energy. Nuclear power today comes from the energy released by the splitting of heavy atoms, like uranium. But energy can also be released by combining, or 'fusing', lighter atoms. This kind of fusion is the source of all the energy we receive from the sun, and researchers in many countries are cooperating to find out how to put it to use on earth.

The Canadian fusion program, which provides yet another option for Canada's energy future, recognizes the importance of investing in the early development of fusion technology. For its size, our program has been hugely successful. The strategy of concentrating research efforts on areas of Canadian expertise has enabled Canadian science and industry to make significant contributions in the field. Because of this R&D work, Canadian industry will be in a position to provide fuel systems to any country that successfully commercializes fusion.

Canada participates actively in the International Energy Agency and has recently become a member of ITER, the International Thermonuclear Experimental Reactor being designed by Japan, the European Economic Community, the United States and the Soviet Union. Our participation in fusion research has already enabled several Canadian companies to win international high-technology contracts. Funding for fusion is provided by the federal Energy R&D Program, Hydro-Québec, Ontario Hydro and the government of Ontario.



The Tokamak de Varennes, located at the Institut de recherche d'Hydro-Québec (IREQ).

Carrying out tritium work at the Fusion Breeder Blanket Program, NRU Reactor at the Chalk River Nuclear Laboratories.

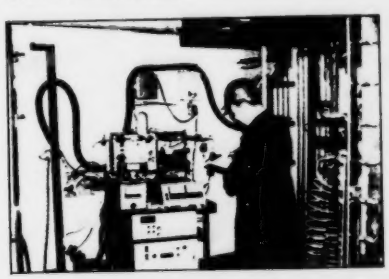
Fusion

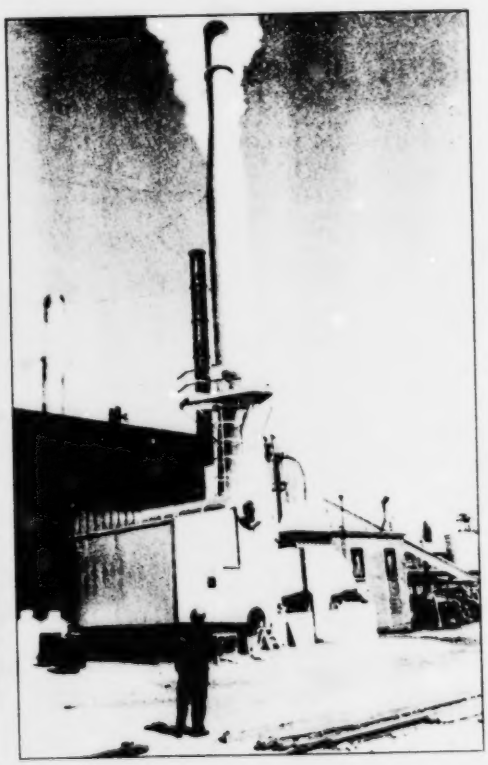
Canadian magnetic fusion research is centred in Varennes, Quebec at the Tokamak de Varennes test facility. Located at the Institut de recherche d'Hydro-Québec (IREQ), the Tokamak de Varennes project will contribute to international fusion R&D through experiments that require access to an electric grid the size of Hydro-Québec's.

The Tokamak, a doughnut-shaped fusion machine, has been designed and built by IREQ in collaboration with the Institut national de la recherche scientifique (INRS), the Université de Montréal, MPB Technologies Inc. and Canatom Inc.

Coal-Water Fuel

Oil shortages in Atlantic Canada stimulated the use of coal in commercial boilers designed for fuel oil. Thin mixtures (slurries) of pulverized coal in water had shown promise as a fuel oil replacement, but stabilization of the slurry and lack of wear-resistant burner systems inhibited practical use. The cooperative development of reliable burners, control systems and stable slurries by NRC, the Canada Centre for Mineral and Energy Technology (CANMET), Cape Breton Development Corporation, Nova Scotia Mines and Energy, and Minas Basin Pulp and Power Company has resulted in the successful operation of the Minas Basin package boiler on both oil and coal-water fuels. This system saves energy (the boiler can automatically follow steam needs in the process plant), reduces sulphur dioxide and nitrogen oxide emissions, and provides process steam generating plants with the practical option of using coal. In the course of this development, advances were also made in coal grinding and additive systems, which are applicable to other Canadian coals.

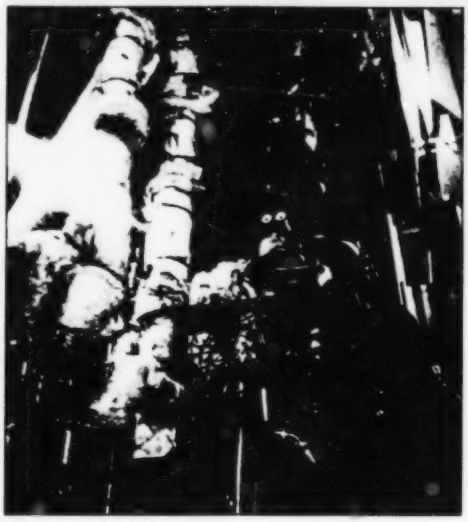




CANMET operators testing the burning of coal-water slurries at Hantsport, N.S.

Hydrocracking

The Canadian oil sands are one of the world's major fuel resources. Although bitumen is now being successfully extracted and converted into synthetic crude oil, the processes are difficult, expensive and environmentally challenging. Many opportunities remain for increasing the efficiency with which we exploit this huge Canadian energy resource.



Many groups in industrial, university and government laboratories are pursuing these challenges, applying unusual and innovative expertise from many fields of science and technology. Drawing on its expertise in catalyst and coal chemistry, CANMET has developed a promising hydrocracking process that increases liquid fuel yields and reduces waste coke levels. It is being evaluated in a 5000-barrel-per-day plant in Montreal.

Hydrogen

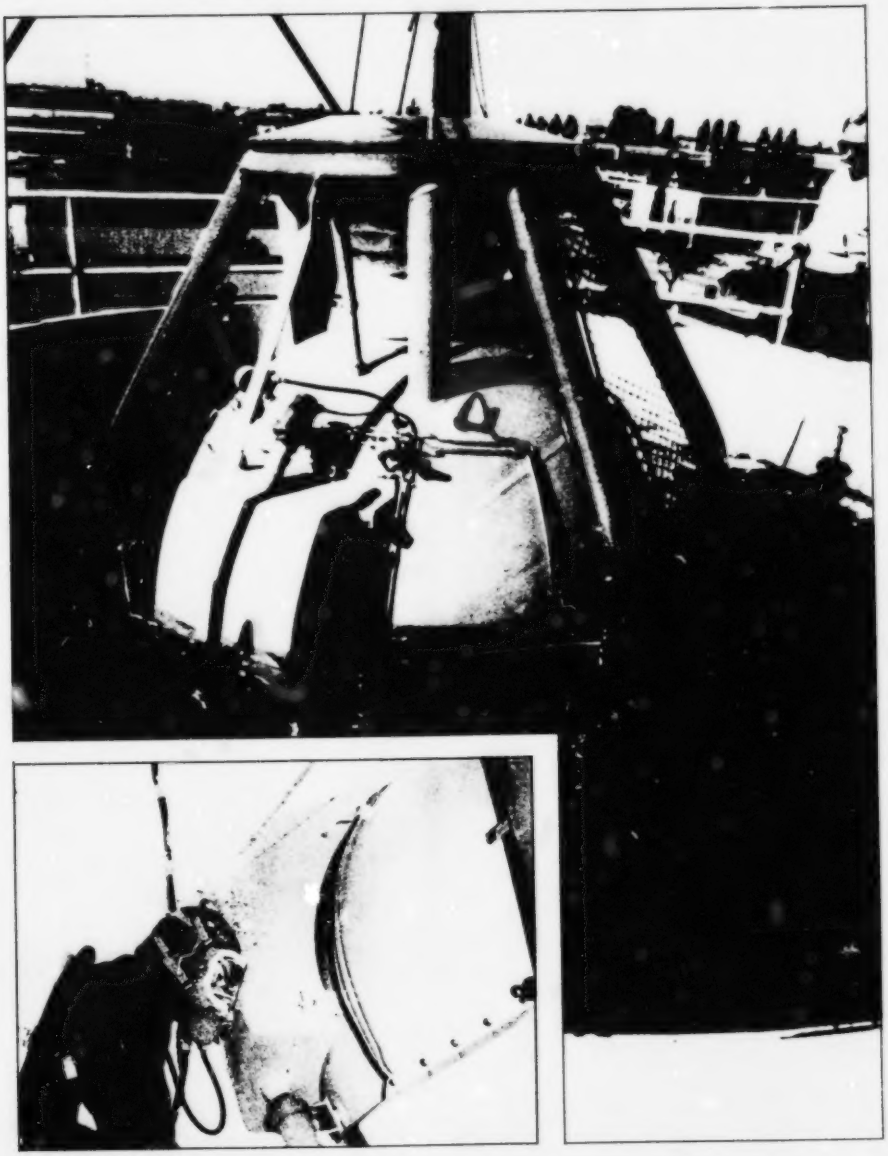
We already put hydrogen to use in the oil, chemical and food industries. It is used to make ammonia for agricultural fertilizers; in the aerospace industry, it fuels rocket engines. Future applications of hydrogen, however, may be much broader than those of today.

Because burning hydrogen results in almost pollutionless byproducts, and because it can be generated by the electrolysis of water, many scientists see hydrogen as a possible base for our transportation energy. And indeed, if oil and gas reserves become depleted, or if increased fossil-fuel burning causes the climate to change more than we'd like, our economy may eventually be driven by electricity and hydrogen. Energy R&D supports the development of electrolytic cells, hydrogen storage and combustion, and fuel cells.

Improving Our Standards

This century has seen a general improvement in working conditions and a remarkable reduction in occupational accidents. By specifying and enforcing industrial health and safety standards, the federal government has raised national levels of well-being, confidence and productivity.

To be effective, standards must be correct, current and amendable. Technology has shown itself to be as important in setting these standards as it is in meeting them. It not only helps us to improve conditions; it also tells us which conditions need to be improved. The federal Energy R&D Program, working closely with some of Canada's more hazardous industries, has been instrumental in furthering technology in both of these areas, and thus in raising the level of health and safety throughout the country.

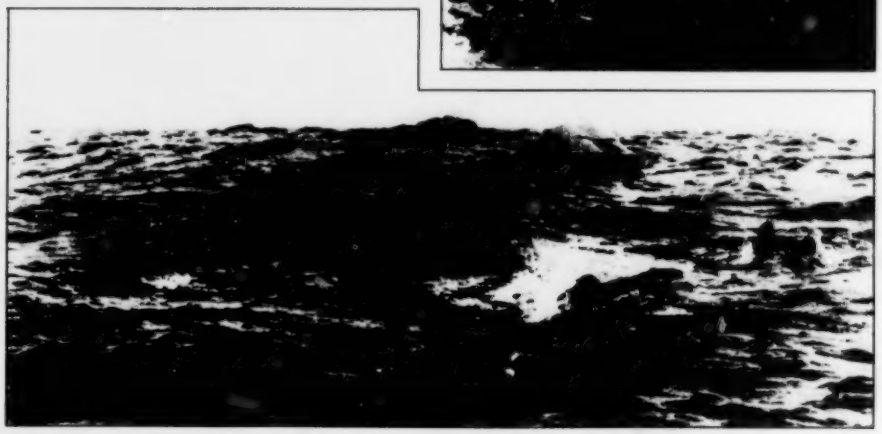


Improved diving bells for offshore oil and gas development.

Offshore Safety

While offshore oil exploration is conducted all over the world, Canadian conditions are unique. Operating in the North Atlantic, Canada's offshore oil rigs must cope with fog, icebergs, cold weather, pack ice and frequent storms.

Although no measures can guarantee safety in such a harsh and uncertain environment, the oil and gas industry, in cooperation with the federal government, has greatly improved working conditions through new technology in offshore diving, emergency rig evacuation, weather and ice forecasting, and search and rescue.



Putting R&D to the test:

Arktos amphibious rescue vehicle.

Survival suits at sea.

All offshore units are now equipped with escape capsules.

Storms

Storms play havoc in the Atlantic region. Not only do they hamper regular shipping and shoreline activities; they also affect offshore oil and gas developments.

Most storms are highly unpredictable, and relatively little is known about the rapid changes in wind speed and wave behaviour they undergo in moving offshore.

In 1986 the Energy R&D Program helped support a major storm research undertaking. It was managed by Environment Canada and Fisheries and Oceans, and was known as the Canadian Atlantic Storms Project (CASP).

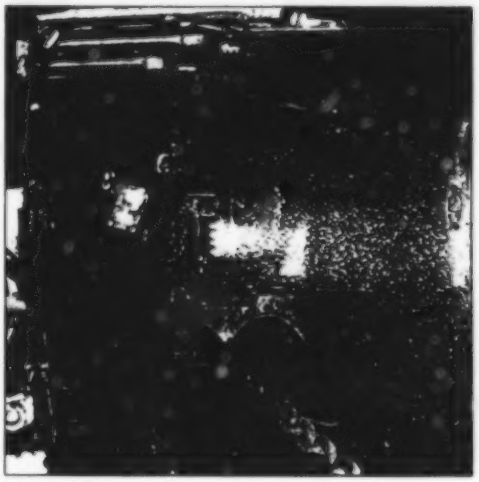
The Royal Commission on the *Ocean Ranger* Marine Disaster made direct reference to CASP in pointing out the value of large interdisciplinary efforts.

"Projects of this nature," said the commission report, "hold considerable promise for improving forecast quality along the Atlantic Seaboard and consequently for promoting the cause of safety."

A major storm in the North Atlantic.

Coal Mine Safety

In addition to technological developments in coal coking and combustion and the removal of sulphur, the Energy R&D coal program assists the Cape Breton Development Corporation in safety improvements in underground mining. The program helped develop seals to inhibit the migration of methane from completed longwall operations. This underground development work places heavy emphasis on more reliable equipment, remote-handling control systems, rock-bolting methods and strata reinforcement.



Cutting coal in the Lingan mine, Cape Breton, N.S.

Indoor Air Quality

With the oil price shocks of the early '70s came the need to lower indoor heating costs. Our first response was to tighten buildings and reduce ventilation. Energy savings, however, were accompanied by new health costs. At the time, we didn't understand the effect these new sealing measures would have on indoor air quality. Now we know better: Where circulation is inadequate, air pollutants can accumulate.

These pollutants, which cause problems in houses and large buildings alike, take many forms and come from a variety of sources. Gases can occur as a result of unvented space heaters, gas stoves, chimney backdrafting, or resins used in building materials. Bacteria can emanate from humidification systems. Mould and mildew can grow on wet surfaces in bathrooms and basements, and within the frame of the building. Smoking, cooking and cleaning can all lower the quality of air.

Developed by Health and Welfare Canada and Concord Ltd., this system provides test atmospheres to calibrate equipment for measuring pollutants.

R&D has been aimed at the identification, origins and control of these pollutants. As a result of this work, Canada has recently issued the world's first air-quality standards for residential buildings. As we learn more about the possible pollution risks, further regulations will be developed to protect public health, and new technology will be brought to bear on many current problems. For example, air-to-air exchangers should provide a means of improving poor air quality; and R-2000 homes incorporate much of this technology.

Preserving Our Heritage

The Canadian public is more concerned about the environment today than at any other time in history. Oil spills, possible global changes in climate caused by the greenhouse effect, contamination by nuclear waste products, acid rain—these problems receive widespread publicity and provoke discussion and debate throughout the country. All of this attention has led to a general understanding that social, economic and environmental considerations are fundamentally connected, and that this connection can be perilous to ignore.

In the field of energy, the public looks to government for decisions that will encourage the reasonable pursuit of economic interests, while prohibiting activities that damage the environment. Such decisions require the establishment of standards, which in turn require the knowledge afforded by scientific research and development.

As standards are subject to change and knowledge is always expanding, prudent energy decisions depend on the development of a strong national technology base maintained by a high level of R&D. Only so can impartial scientific evidence be used to effect a wise balance between competing interests, and only so can future decisions adequately serve Canada's short- and long-term needs.

The federal Energy R&D Program, of which more than half is related to environmental issues, assists Canada in understanding the environmental constraints on energy supply and use; developing technology that is more environmentally benign; approaching environmental problems from a national, continental and global perspective; and adopting policies that promote sustainable economic development, energy diversification and environmental well-being.

FORCYTE

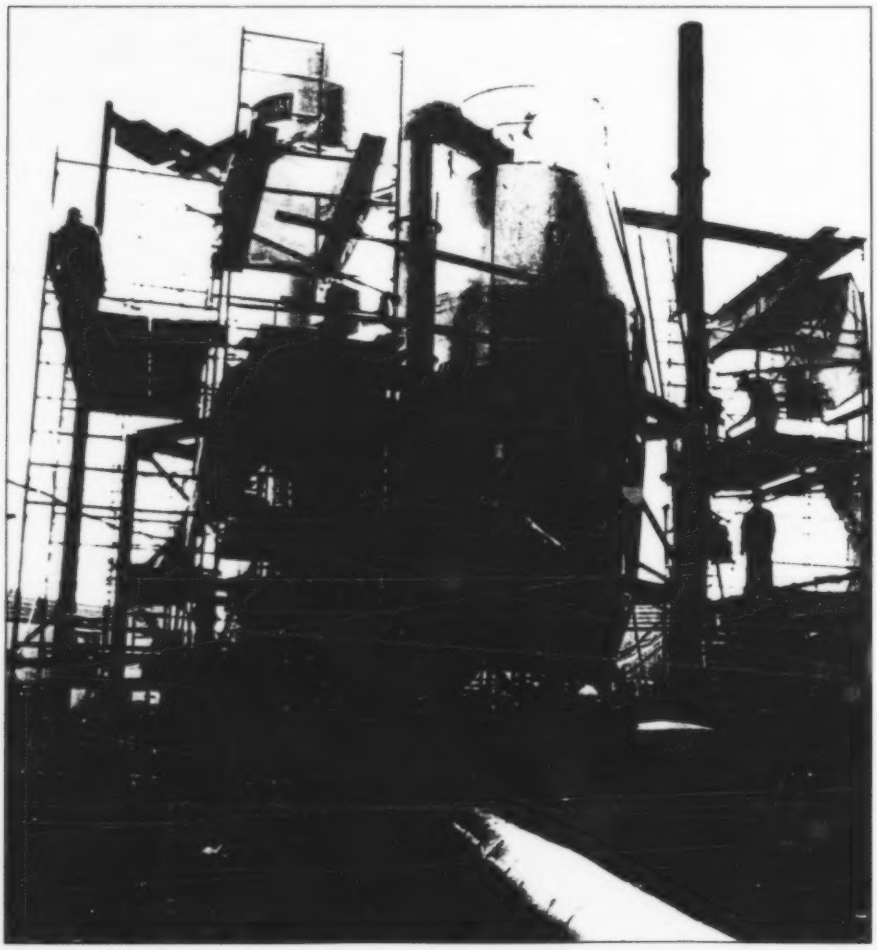
Forests provide an important renewable source of energy. But it is uncertain how future energy demands will affect the forest environment. To assist in predicting future growth and yields under changing conditions, the FORCYTE (Forest Nutrient Cycling and Yield Trend Evaluator) series of computer simulation models has been developed for Forestry Canada as part of the ENFOR program of bioenergy R&D. This model can describe all aspects of forestry practice, and has attracted worldwide recognition for its potential application to forest ecosystems.

Energy from Municipal Solid Waste

One of the serious environmental problems facing almost all communities is the disposal of municipal solid wastes. Disposal by landfill spoils land and can lead to groundwater contamination. Complete recycling is extremely expensive. Combustion combined with recycling, though difficult, now appears to be the most prudent option. Incineration systems can reduce landfill waste by up to 90% and recover energy as well.

In order to learn how to reduce emissions from waste burning to safe levels, Environment Canada decided to make a full study of the design, operation and environmental effects of incinerators. To carry out the work, the department established the National Incinerator Testing Program (NITEP).

This work has proved to be some of the most advanced of its kind in the world, establishing conditions for incinerating all manner of municipal wastes in a safe and environmentally acceptable way. NITEP's results have made Canada a leader in the field, brought cooperation with the U.S. Environmental Protection Agency, and encouraged Quebec City, Hamilton and Parkdale, P.E.I., to adopt these technologies for their incinerators.



In cooperation with Flakt Canada, NITEP studies were conducted at this part of the municipal solid waste plant in Quebec City.

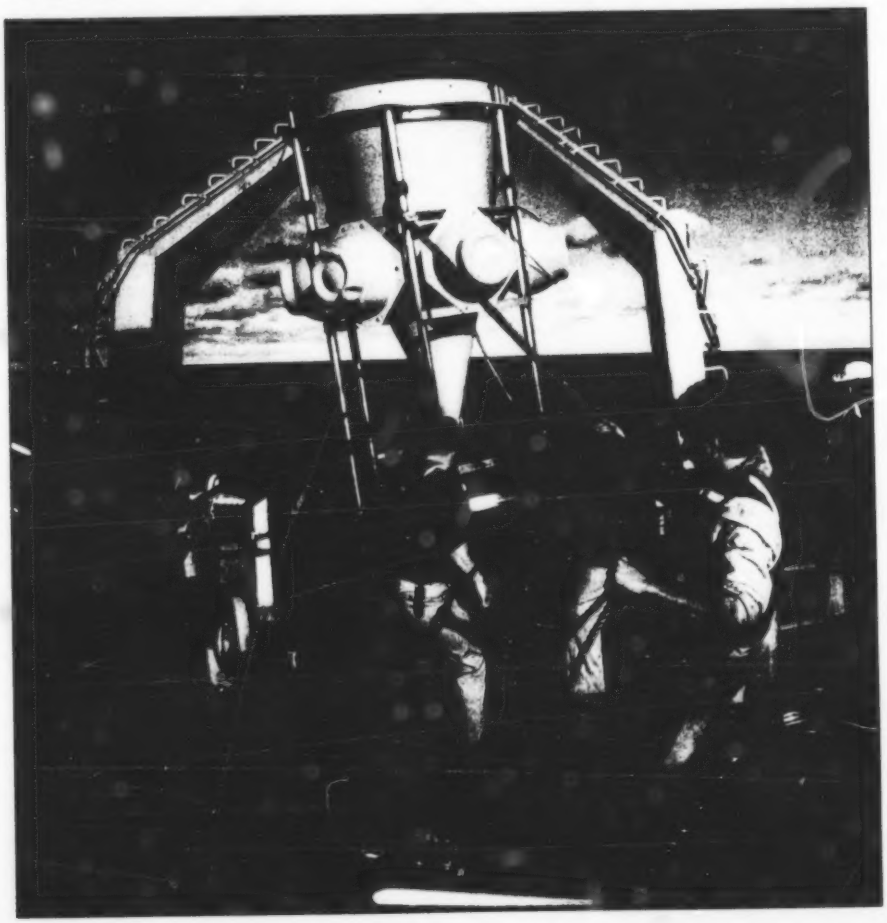
The Greenhouse Effect

We have always known that the earth's climate affects us all, sometimes more than we'd like. Until recently, however, few people realized that we also affect the climate.

The rapid rise in population, the increased burning of fossil fuels, deforestation and certain industrial processes have produced changes in the blanket of gases that surrounds our planet. This is called the greenhouse effect, and it is now believed to lead to global warming.

As for what these changes are going to mean, so far we can't say for sure. The earth's climatic system is extremely complex, and we still don't understand exactly how it works, or exactly how our behaviour will affect it. We do know, however, that our ability to respond to what could be major changes in our climate depends directly on the currency of our science and technology.

For this reason, the federal Energy R&D Program supports climatic studies in cooperation with Environment Canada. The climatic program consists of an atmospheric section (under Environment Canada), which measures carbon dioxide changes in the air; and an oceanic section (under Fisheries and Oceans), which measures carbon dioxide levels in the Pacific and quantifies its absorption in oceans and in ocean sediments.



Measuring carbon dioxide in the Pacific Ocean to study the greenhouse effect.

Energy from Old Tires

Modern society creates many products that are designed to withstand hard use but that eventually wear out and then create disposal problems. The automobile tire is a good example. Old tires are now practically worthless; in fact they often cause communities additional costs. They are difficult to grind up; they do not decompose; and in large city dumps they provide an ideal environment for fire and vermin.

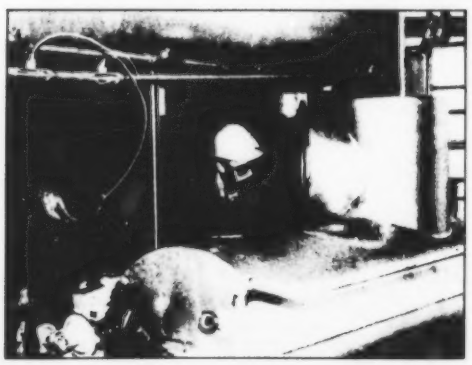
Several groups are attempting to resolve this problem. One of these, which has been supported by the Energy R&D Program, is led by Professor Christian Roy of Laval University . His vacuum pyrolysis process converts old tires into fuel oil, gas, scrap steel and a reusable low-grade carbon black. It is now being evaluated at the pilot plant stage as a means of providing reusable products while affording a solution to a tough environmental problem.

Oil from Sewage Sludge

Environment Canada has found a way of producing usable fuel from a most unlikely substance: sewage sludge.

Sewage sludge is a byproduct of the wastewater treatment processes used to render industrial and municipal wastewaters less harmful to the environment. Every year Canada produces some 500 000 tonnes of sludge, and spends about $100 million to dispose of it.

Offering an efficient alternative to landfill, ocean-dumping and incineration disposal methods is the 'oil from sludge' technology developed at Environment Canada's Wastewater Technology Centre in Burlington, Ontario. Dried sludge is heated in an oxygen-free environment for about thirty minutes, reducing the natural oil-forming process by several million years to produce a usable furnace oil. Methane and char, both of which have energy value, are also produced.



Pilot plant at Burlington, Ont. for converting sewage sludge into fuel.

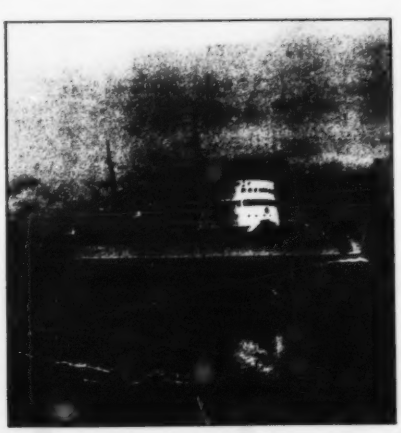
Aside from the economic utility of the products, sludge conversion is particularly valuable as an environmentally acceptable and lower cost way of disposing of this difficult product of our society. This type of sludge conversion is expected to gain wide acceptance; considerable interest has already been expressed by Canadian, U.S., and Australian municipalities.

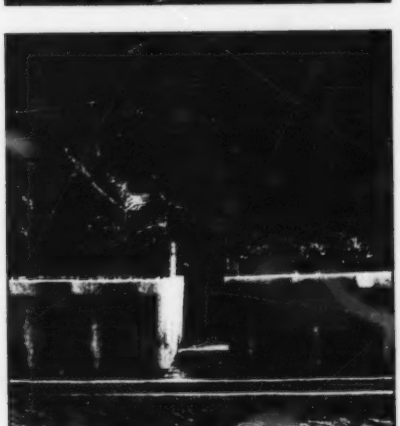
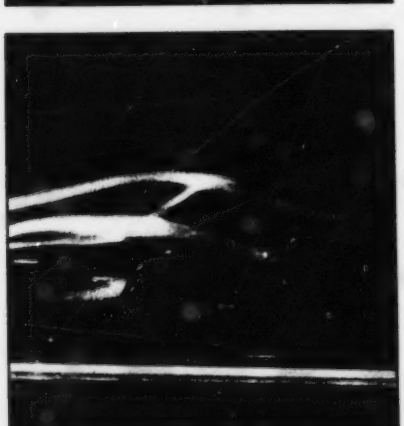
Some Future Technologies

The examples in this brochure have illustrated some of the results of the federal Energy R&D Program. Many other projects are in progress, and many emerging areas have the potential to further improve our energy economy in the future.

For example:

- Lasers in large-scale chemical processing
- Conversion of methane to liquid hydrocarbons
- Synthetic lubricants
- Electrorheological fluids
- Ceramic low-heat rejection engines
- Pipelining solids
- 'Super' windows
- High power-to-weight ratio engines fueled by hydrogen
- Enzyme-catalyzed separations
- High-power density batteries
- Understanding climatic variation
- Super-conducting magnetic energy storage
- Plasma smelting
- Low- or zero-tillage systems
- Advanced bitumen extraction and upgrading systems
- Biological pesticides
- Reforestation on desert margins
- Thermonuclear fusion
- Advanced photovoltaic systems
- Piezoelectric ceramics
- Refrigerants with minimal effects on the ozone layer
- Waste sorting and disposal



International Energy Agency Agreements for Cooperative R&D in Which Canada is a Participant

International agreements help Canada to avoid duplication of R&D efforts, cutting costs and saving valuable time.

End-Use Technologies

- Centre for the Analysis and Dissemination of Demonstrated Energy Technologies
- Buildings and Community Systems
- Advanced Heat Pumps
- Energy Conservation in Combustion
- Heat Transfer/Heat Exchangers
- Pulp and Paper
- District Heating
- Alcohol and Alcohol Blends as Motor Fuels

Renewable Energy

- Bioenergy
- Hydrogen
- Large-Scale Wind
- Peat Production
- Small Solar Power Systems
- Solar Heating and Cooling
- Wind Energy R&D

Fossil Fuels

- Coal Technical Information Service
- Coal Pyrolysis
- Enhanced Oil Recovery
- Atmospheric Fluidized Bed Combustion
- Control of NO_x Emissions during Coal Combustion
- Coal/Oil Mixtures
- Coal Combustion Sciences
- Multiphase Flow Sciences

Fusion Power

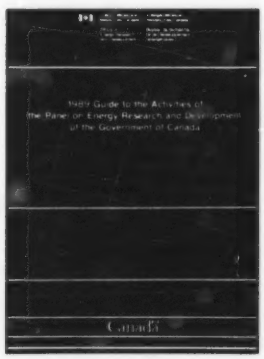
- Radiation Damage in Fusion Materials
- Textor

General

- Energy Technology Data Exchange
- Systems Analysis

Federal Departments and Agencies Which Have Participated in the Interdepartmental Panel on Energy R&D

Agriculture Canada (AC)
Atomic Energy of Canada Ltd. (AECL)
Canada Mortgage and Housing Corporation (CMHC)
Consumer and Corporate Affairs Canada (CCA)
National Defence (DND)
Environment Canada (EC)
Energy, Mines and Resources Canada (EMR)
Finance Canada (FIN)
Fisheries and Oceans (F&O)
Health and Welfare Canada (HWC)
Industry, Trade and Commerce (ITC)
Indian and Northern Affairs Canada (INA)
Science and Technology Canada (MOSST)
National Research Council Canada (NRC)
Public Works Canada (PWC)
Regional Industrial Expansion (DRIE)
Supply and Services Canada (SSC)
Transport Canada (TC)
Treasury Board Secretariat (TBS)



Guide to the Panel on Energy Research and Development

Programs Carried Out by the Federal Panel for Energy R&D

The work of the interdepartmental panel on Energy R&D is managed as six major tasks. The principal topics are summarized as follows.

Task 1: Energy Efficiency

- Industry Energy R&D Program
- Industry
- Agriculture and food (including fishing)
- Buildings
- Transportation
- Energy systems

Task 2: Coal

- Coal technologies
  - . resource assessment
  - . coal mining
  - . preparation transport
  - . coal combustion
- Environmental aspects of mining, preparation and transportation

Task 3: Fusion

- Magnetic confinement programs
- Fusion fuels technology programs
- International cooperative projects with the IEA and through bilateral work with the U.S., Europe and Japan

Task 4: Renewable Energy and Generic Environment

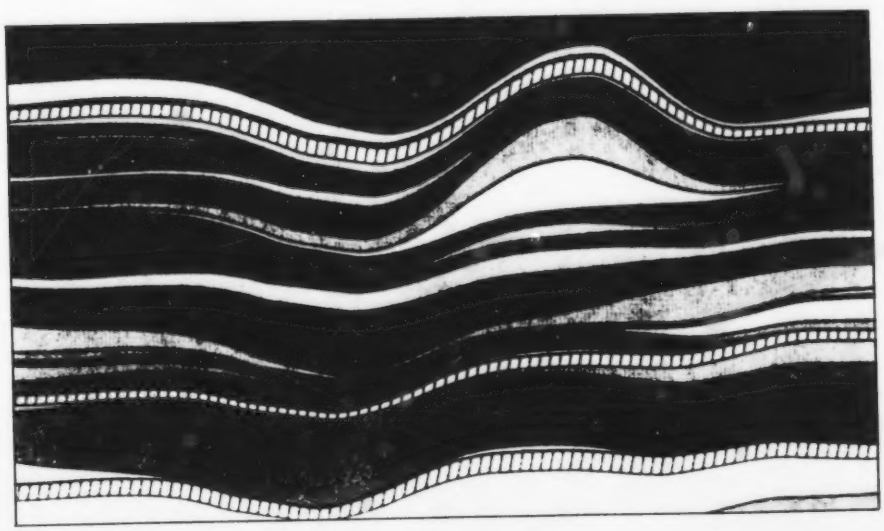
- Hydraulics
- Active solar
- Passive solar
- Photovoltaics
- Bioenergy
- Wind
- Geothermal
- Generic environment

Task 5: Alternative Transportation Fuels

- Hydrocarbons enhancement
- Bitumen, oil recovery, upgrading
- Fuel use
- Hydrogen and energy storage
- Environment

Task 6: Oil, Gas and Electricity

- Geoscientific R&D
- Marine engineering
- Offshore geotechnics
- Materials
- Transportation of oil and gas
- Environment
- Electricity



Coal resource charts developed by the Institute for Sedimentary and Petroleum Geology, Calgary.

This brochure has attempted to describe some of the work supported by the Interdepartmental Panel on Energy R&D during the last several years. But though we have tried to be representative, it was simply not possible to do justice to the program in a publication of this kind. Fortunately, there are other publications, some pictured on this page, that present the many sides of the program in greater detail.

CARBURANT DE RECHANGE
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AU SEUIL DU XXIe SIÈCLE
SIXTH CANADIAN BIOENERGY R&D SEMINAR
SIXIEME SEMINAIRE CANADIEN DE R&D EN BIOENERGIE
CECILE GRANGER
NEWSLETTER
Technologie des énergies de remplacement au Canada

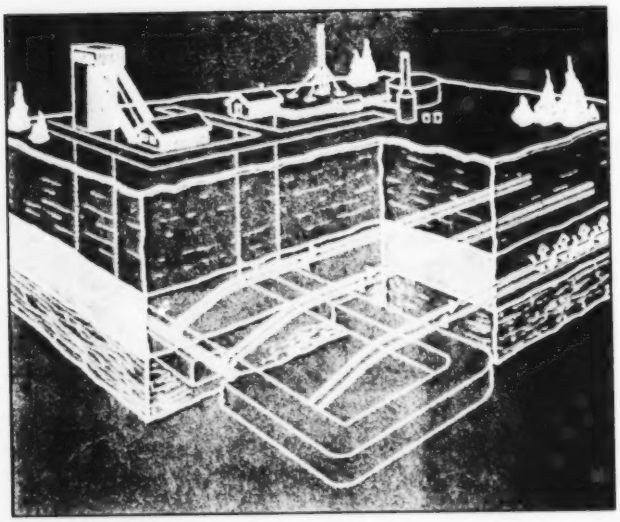
For further information on any aspect of the Energy R&D Program, including the work summarized in this booklet, or for copies of the guide to the program, please contact :

Director General

Office of Energy Research and Development

Energy, Mines and Resources Canada
580 Booth Street
Ottawa, Ontario
K1A 0E4

Tel: 613-995-8860
Fax: 613-995-6146



Although the Athabaska reservoir is one of the world's largest hydrocarbon deposits, much of the bitumen and heavy oil is too deep for surface mining.

The photograph and illustration above show the facility operated by Alberta Oil Sands Technology and Research Authority (AOSTRA) and industrial partners to evaluate a range of steam injection technologies as a means of recovering bitumen too deep for surface mining.